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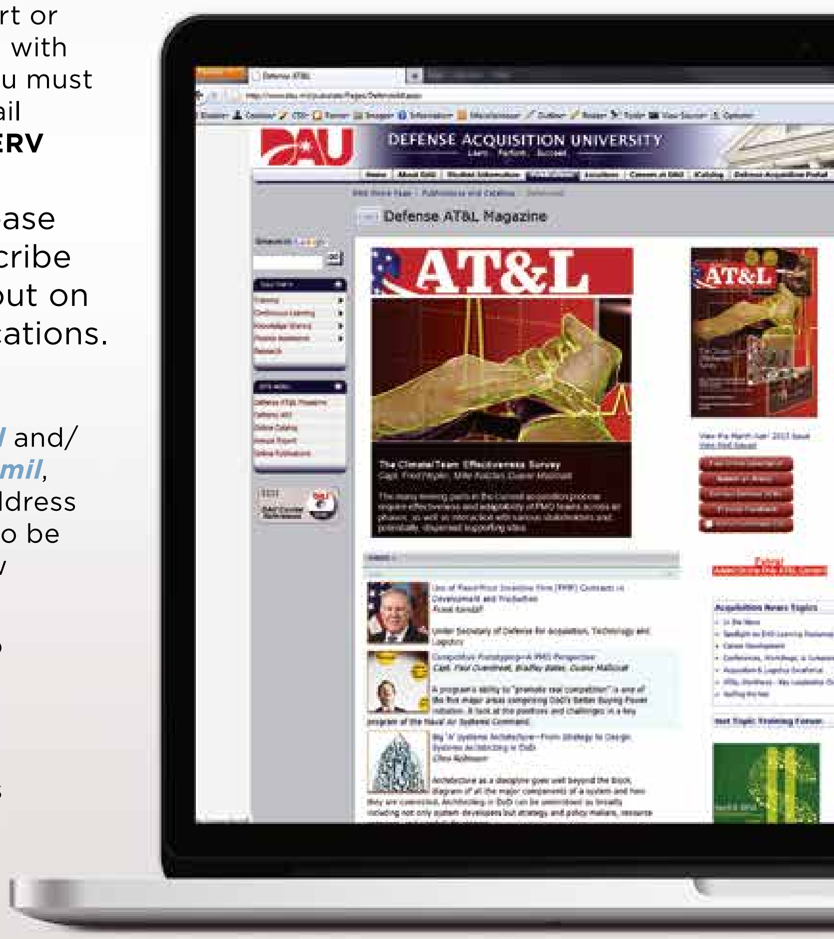

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- System Cyber Hardness

GROUND RULES

- The competition is open to anyone interested in the DoD acquisition system and is not limited to government or contractor personnel.
- Employees of the federal government (including military personnel) are encouraged to compete and are eligible for cash awards unless the paper was researched or written as part of the employee's official duties or was done on government time. If the research effort is performed as part of official duties or on government time, the employee is eligible for a non-cash prize, i.e., certificate and donation of cash prize to a Combined Federal Campaign registered charity of winner's choice.
- First prize is $1,000. Second prize is $500.
- The format of the paper must be in accordance with guidelines for articles submitted for the *Defense Acquisition Research Journal*.
- Papers are to be submitted to the DAU Director of Research: research@dau.mil.
- Papers will be evaluated by a panel selected by the DAUAA Board of Directors and the DAU Director of Research.
- Award winners will present their papers at the DAU Acquisition Community Training Symposium, Tuesday, April 8, 2014, at the DAU Fort Belvoir Campus.
- Papers must be submitted by December 16, 2013, and awards will be announced in January 2014.

From the Chairman and Executive Editor

"Plans are worthless, but planning is everything."[1]
— Dwight D. Eisenhower, 1957

The ever-quotable Dwight D. Eisenhower, speaking to a group of industry executives who could be mobilized for war at a moment's notice, was echoing an old adage about warfare: "No battle plan survives first contact with the enemy."[2] Eisenhower's message, like the man himself, was straightforward: "The reason it is so important to plan [is] to keep yourselves steeped in the character of the problem that you may one day be called upon to solve—or to help to solve." He was reminding them that warfare is inherently fluid, and that the only way to adjust to quickly changing circumstances is to have planned for such contingencies in advance.

Like warfare, defense acquisition has always been changeable, but in the post-Cold War era it has become largely unpredictable from one year to the next. The fiscal, political, and economic climates in which it now operates vary so widely and change so quickly, that clear-headed planning, which explicitly accounts for such variability, is needed more than ever.

The first article in this journal, "Strategic Planning and Management in Defense Systems Acquisition" by Stanley G. Rosen, surveys the landscape of how planning tools such as root cause analyses and mission/strategy mapping are viewed and used by defense acquisition professionals. Next, "Improving Program Success Through Systems Engineering Tools in Pre-Milestone B Acquisition Phase," by Daniel Deitz et al., proposes systems engineering methods for planning in the early development phase of acquisition that widen the solution space and improve risk characterization. Roy L. Wood, in "Time Is Money," argues that "time certain development" periods on the order of 6 years, give program managers a better handle on cost and schedule planning.

The next article, "Are the Performance Based Logistics Prophets Using Science or Alchemy to Create Life-Cycle Affordability? Using Theory to Predict the Efficacy of Performance Based Logistics," by Wesley S. Randall, uses theory to predict the efficacy of performance based logistics and suggests several lines of theoretical work from the economic and business disciplines that can improve predictive capabilities for logistics planning. Meanwhile, contract planning performed

downrange in contingency and expeditionary operations should be executed by high-level personnel in Congressionally mandated field positions, argue E. Cory Yoder, USN (Ret.), and colleagues. Finally, in "OSD's Obligation and Expenditure Rate Goals: A Closer Look at the Causal Factor Groupings and How They Modulate," Col Robert L. Tremaine, USAF (Ret.) and Donna J. Kinnear-Seligman report on an Office of the Secretary of Defense (OSD)-initiated study to examine one of the benchmarks used to help weapon systems program offices maintain the required execution pace of appropriated funding.

The featured book in this issue's Defense Acquisition Professional Reading List is J. Ronald Fox's *Defense Acquisition Reform, 1960–2009: An Elusive Goal* (2011), reviewed by John Alic.

There have been several changes to our masthead. First, Dr. William A. LaPlante, Principal Deputy Assistant Secretary of the Air Force (Acquisition), has replaced Mr. David M. Van Buren on our Research Advisory Board. Second, Mr. Jerry Vandewiele has replaced Dr. Don McKeon as the DAU Midwest representative on our Editorial Board. Third, Dr. Neal Couture of The George Washington University and Dr. Aude-Emmanuelle Fleurant of the France's War College Strategic Research Institute (Institut de Recherche Stratégique de l'Ecole Militaire) have also been added as new members of the Editorial Board. We greatly appreciate the service and continued support of the outgoing board members, which is critical to the processing and publication of the *Defense Acquisition Research Journal,* and look forward to the contributions of the newest board members.

Dr. Larrie D. Ferreiro
Executive Editor
Defense ARJ

[1]Eisenhower, D. D. (1957, November 14). Remarks at the National Defense Executive Reserve conference. Online by G. Peters and J. T. Wolley, *The American Presidency Project* at http://www.presidency.ecsb.edu/ws/?pid=10951.

[2]Von Moltke, H. (1897). Militarische Werke (Vol. I). *Militarische Korrespondenz.* Berlin: E. S. Mittler.

DAU Center for Defense Acquisition Research

Research Agenda 2013

The Defense Acquisition Research Agenda is intended to make researchers aware of the topics that are, or should be, of particular concern to the broader defense acquisition community throughout the government, academic, and industrial sectors. The purpose of conducting research in these areas is to provide solid, empirically based findings to create a broad body of knowledge that can inform the development of policies, procedures, and processes in defense acquisition, and to help shape the thought leadership for the acquisition community.

Each issue of the Defense ARJ will include a different selection of research topics from the overall agenda, which is at: http://www.dau.mil/research/Pages/researchareas.aspx

Affordability and cost growth

- Define or bound "affordability" in the defense portfolio. What is it? How will we know if something is affordable or unaffordable?

- What means are there (or can be developed) to measure, manage, and control "affordability" at the program office level? At the industry level? How do we determine their effectiveness?

- What means are there (or can be developed) to measure, manage, and control "Should Cost" estimates at the Service, Component, program executive, program office, and industry levels? How do we determine their effectiveness?

- What means are there (or can be developed) to evaluate and compare incentives for achieving "Should Cost" at the Service, Component, program executive, program office, and industry levels?

- Recent acquisition studies have noted the vast number of programs and projects that do not make it successfully through the acquisition system and are subsequently cancelled. What would systematic root cause analyses reveal about the underlying reasons, whether and how these cancellations are detrimental, and what acquisition leaders might do to rectify problems?

- Do Joint programs—at the inter-Service and international levels—result in cost growth or cost savings compared with single-Service (or single-nation) acquisition? What are the specific mechanisms for cost savings or growth at each stage of acquisition? Do the data support "jointness" across the board, or only at specific stages of a program, e.g., only at research and development or only with specific aspects, e.g., critical systems or logistics?

- Can we compare systems with significantly increased capability developed in the commercial market to DoD-developed systems of similar characteristics?

- Is there a misalignment between industry and the government priorities that causes the cost of such systems to grow significantly faster than inflation?

- If so, can we identify why this misalignment arises? What relationship (if any) does it have to industry's required focus on shareholder value and/or profit, versus the government's charter to deliver specific capabilities for the least total ownership costs?

DEFENSE ACQUISITION RESEARCH JOURNAL

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Keywords: *Strategic Planning, Strategic Management, Strategy, Effectiveness, Management Tools*

Strategic Planning and Management in Defense Systems Acquisition

Stanley G. Rosen

Strategic Planning and Management (SP&M) methods are widely used in the commercial sector and are a required organizational activity within the U.S. Government. More specifically, defense acquisition organizations use SP&M methods to strengthen the management of defense acquisition organizations/programs. This article reports results of a survey of the defense acquisition community that assessed how SP&M methods and practices promote management effectiveness. The results show that SP&M is viewed as valuable to Department of Defense system acquisition programs and organizations. Moreover, this effort identified high-value activities, tools, processes, practices, and common roadblocks to effective SP&M. These results imply that training on processes and tool use can be very important, especially for senior leaders, and implementation assistance can also be useful.

Image designed by Diane Fleischer »

For the purpose of this effort, Strategic Planning and Management (SP&M) is a set of processes that includes strategic planning, where managers jointly formulate their strategy; and strategic management, the implementation or execution of the strategic plan. These two processes, formulation and implementation, are both mutually essential. Planning without implementation is useful, but fruitless; implementation without planning is chaotic.

Based on those definitions, SP&M has the following key characteristics:

- Positions the organization through strategy and capability planning;
- Responds to real time strategic issues; and
- Tackles systematic management of resistance during strategic implementation.

Strategic planning, according to Dr. John Bryson (2010), offers many benefits to public-sector organizations:

- Promotes strategic thinking, acting, and learning;
- Improves decision making;
- Enhances organizational effectiveness, responsiveness, and resilience;
- Improves organizational legitimacy; and
- Benefits people directly involved.

Bryson, a strategic planning researcher from the University of Minnesota, states, "Evidence indicates that when strategic planning is seen as a practice that is improved by reason-based advice, it is one of the very useful ways in which imperfect people can cope pretty well with . . . 'insoluble' problems" (Bryson, 2010).

A growing number of studies indicates that strategic planning works in a variety of situations, and that successful linkage to strategic visioning, long-range planning, budgeting, and implementation promotes organizational and technological innovation. Strategic planning has become ubiquitous in the public sector over the past 25 years—with extensive practical experience in managing effective organizational change in general, and with strategic planning in particular—and has proven its value (Barzelay & Campbell, 2003; Berman & West, 1998; Berry & Wechsler, 1995; Boyne & Gould-Williams, 2003; Bryson, 2004; Campbell, 2000; Friedman, 1987; Mulgan, 2009; Wechsler & Backoff, 1987).

In fact, the recognition is evolving that transition is needed from strategic planning to the broader process of strategic management, which focuses the organization on implementation of the strategic plan. According to Theodore Poister (2010), strategic management promotes effective strategy implementation, is ongoing rather than episodic, and focuses on achieving strategic goals and objectives rather than on measurement. In fact, evidence indicates that performance monitoring through measurement informs strategy (Moynihan, 2008).

The effectiveness of modern strategic management methodologies has been well documented (Eden & Ackerman, 1998; Meier & O'Toole, 2002; Nutt & Backoff, 1992; Poister, Pitts, & Edwards, 2010). Schmidt (2009) has written extensively about the benefits of applying strategic management principles to project management. These practices help address key issues, including

- What are we trying to accomplish and why?
- How do we measure success?
- What other conditions must exist?
- How do we get there?

The work of Rollinson and Young (2010) identifies key principles for successful strategic management and identifies a comprehensive process for the implementation of these principles. Their discussion of strategic management competencies applies to defense acquisition organizations and programs:

- Identifying, articulating, and developing a core set of shared values;
- Visioning;
- Strategic thinking;
- Identifying and developing core organizational competencies and capabilities;
- Converting information into strategic intelligence;
- Identifying, evaluating, and selecting strategic alternatives; and
- Team work and team building.

Situation

The Department of Defense (DoD) is responsible for effectively using taxpayer dollars to field systems that enhance national security. And the department is constantly striving to find ways to improve performance. Of course, DoD leadership rightly stresses that budget reductions are prompting "doing more with no more" (at best). This is why, among other things, lessons learned from best practices are being emphasized (e.g., "Better Buying Power" initiatives).

Defense systems acquisition is inherently a strategic activity. For example, acquisition programs by definition support organizational (and national) strategies, have long-term implications, and, in general, help create the future. Major acquisitions, in addition, are key to organizational (and national) success, employ significant resources, and command top-level oversight.

Strategic planning and management is key to program acquisition success, both in terms of program success and the success of management organizations. All defense acquisition programs and organizations must succeed in a dynamic environment, with constantly changing requirements, priorities, resources, and other challenges (Schwartz, 2004). This dynamism is the factor that impels the community to apply the best strategic management practices.

For these reasons, we must apply the best strategic management tools and processes to defense systems acquisition activities. Along with other management tools and processes, SP&M should be done well for optimum defense acquisition outcomes.

Methodology

To better understand what practices are succeeding in this community, the Defense Acquisition University (DAU) invited over 3,000 defense systems acquisition personnel who had attended DAU West Region 300-level acquisition courses in Fiscal Years 2008–2011, to respond to an online survey. These more experienced acquisition professionals were likely to have been exposed to the concepts outlined in the research. A broad cross section of acquisition personnel with experience and strategic management expertise were queried for both qualitative and Likert-like quantitative responses. The e-mail invitation explained the researchers were interested in pulsing professionals with SP&M experience.

Responses were received from 412 survey respondents who represented a wide range of Army, Navy, Air Force, and other Defense Department programs and acquisition organizations. Approximately a third of the survey respondents had more than 15 years' experience in acquisition management, with significant experience using strategic planning and/or strategic management methodologies. Responses from participants who indicated no strategic planning or strategic management experience were removed from the survey response data analysis, leaving 295 qualified responses from the population of interest.

After identifying the respondents' organization, program, position, certification level, and experience with SP&M, the survey assessed the perceived usefulness of a wide range of common tools used for SP&M. Both roadblocks and facilitating factors for effective SP&M

were identified, as well as the types of resources needed for effective SP&M. Finally, the survey assessed the overall perceived value of SP&M in defense systems acquisition, as well as specific organizational and program benefits.

Since the intent of the survey was to understand the use of strategic planning and management methodologies in the Defense Department, no private sector inputs were solicited or received.

About 24 percent of the respondents currently hold program manager (PM) or deputy PM positions. Another 23 percent hold positions as functional leads. The remainder comes from a wide array of program office positions.

Respondents also represent a wide cross section of functional areas, although the largest group (33 percent) is in program management. Other well-represented functional areas were life cycle logistics (16 percent) and systems engineering (16 percent). Each of the other functional areas comprised less than 10 percent of the respondents.

Roughly 50 percent of the respondents were certified at Defense Acquisition Workforce Improvement Act Level III, with Levels I and II represented by about a quarter of the respondents each.

Findings

Somewhat surprisingly, many (approximately one-third) of the DoD acquisition professionals who participated in this research project have private-sector experience using strategic planning and management. Their responses highlight many ways in which strategic planning and management considerations in the DoD are both similar and different from those in the other sectors.

Similarities include the observations that there is often a wide gap in understanding of strategic factors between top and working levels, coupled with micromanagement and multilevel approvals in both defense and nondefense organizations. In both types of organizations, participants must comply with specific guidance from others, and decisions often involve big dollars, long timelines, and complex programs. Survey respondents also identified that in both types of organizations, leadership shortcomings and inexperience can impede effective strategic planning and management; and that it is not uncommon to encounter many uncertain, contradictory, and frequently changing factors, including funding, policies, priorities, requirements, and threats.

On the other hand, defense acquisition managers and leaders face some fairly unique challenges. Being responsible to taxpayers is different from being answerable to shareholders, especially since the purpose of defense acquisition activities is national security, not profit- or market-driven considerations.

In fact, respondents noted that sometimes performance must be achieved at all costs, and some situations can have life-or-death implications, including the use of nuclear weapons. Defense acquisition is influenced by national politics and must comply with unique federal regulations, policies, and processes, which involve requirements, budgeting and funding, acquisition/procurement methods, and personnel management issues, including drawdown.

Strategic planning is widely practiced in the defense acquisition community. About 70 percent of the survey respondents reported that their organization has a current strategic plan (although about 20 percent weren't sure).

1

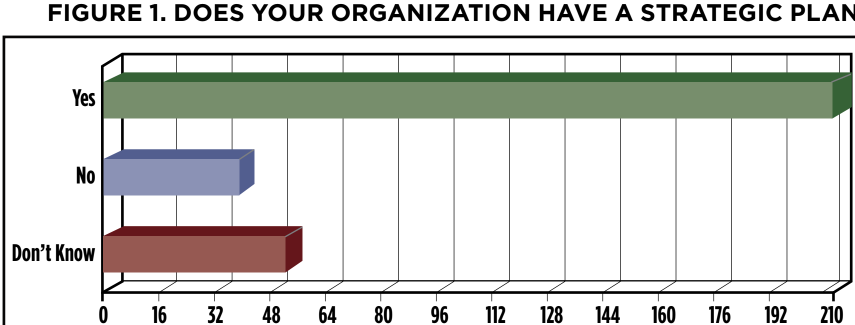
Does Your Organization Have a Strategic Plan?

Of the 70 percent of respondents with current strategic plans, about 90 percent use their strategic plan for either organizational improvement (27 percent), program management (19 percent), or both (44 percent). When asked a broader question about the use of strategic planning and/or strategic management methodologies in general, only 16 percent indicated its use for organizational improvement, whereas over 25 percent use these methods for program management. Moreover, the use of these methods for both organizational improvement and program management grew to 47 percent of the survey respondents.

These results indicate that although strategic planning/management is commonly used to guide organizational development, its frequent use for program management suggests that this is a potentially fruitful area in which to seek opportunities for improvement and cross-community sharing of best practices.

While these results indicate that strategic planning and strategic management methods are being widely applied by the respondents, and, by inference, across our community, it's also useful to understand the respondents' satisfaction with the use of these practices. Although virtually all respondents indicated that they found some value in use of SP&M methodologies, about half of them indicated they highly value these methods for improving program outcomes (a Likert score of 6 or 7 on a 1–7 scale).

FIGURE 1. DOES YOUR ORGANIZATION HAVE A STRATEGIC PLAN?



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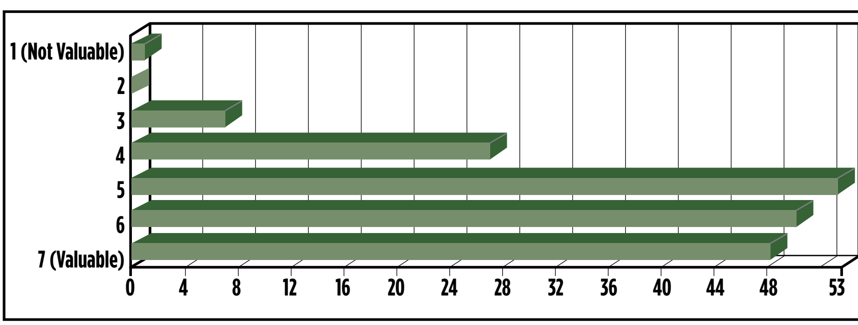
Overall, How Would You Rate Strategic Planning and Management Methodologies in Improving Program Management Outcomes?

The nature of the value provided by use of SP&M methods is quite broad in this community. The most commonly identified benefit, expressed by a full 85 percent of the respondents, was better communications. Closely following that were increased internal efficiencies (76 percent), organizational performance gains (69 percent), major changes to business practices (45 percent), and increased external efficiencies (37 percent).

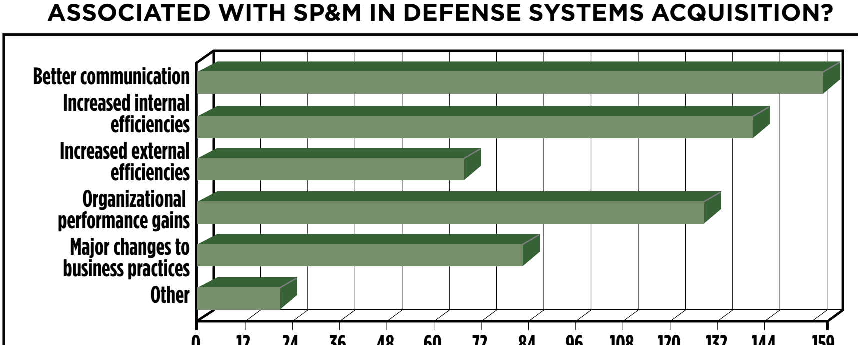
FIGURE 2. OVERALL, HOW WOULD YOU RATE STRATEGIC PLANNING AND MANAGEMENT METHODOLOGIES IN IMPROVING PROGRAM MANAGEMENT OUTCOMES?



What Specific Benefits and Outcomes are Associated with SP&M in Defense Systems Acquisition?

For the specific respondents who gave the highest ratings to the usefulness of SP&M in improving program outcomes, increased internal efficiency and better communications were the most often cited benefit, followed by gains in organizational performance.

FIGURE 3. WHAT SPECIFIC BENEFITS AND OUTCOMES ARE ASSOCIATED WITH SP&M IN DEFENSE SYSTEMS ACQUISITION?



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Many other specific benefits were mentioned, verbatim:

- More efficient execution of funds;
- Helps solidify the resources toward a common goal and priority taskings;
- Improved personnel morale;
- Conserves resources by industry and government working together;
- Team effectiveness
- Better links to future requirements for Program Objective Memorandum and resource planning;
- More knowledgeable workforce;
- Portrays the organization's strategic contributions to national defense;
- Reduces waste, lack of focus, and duplication of effort;
- Gives vector in highly distributed organizations;
- Increases focus on the important vice the urgent;
- Direct, measurable bottom line results;
- Collaboration and coordination with other program management activities;
- Leadership;
- Provides a good roadmap; and
- Prepares agencies during Base Realignment and Closure activities.

The respondents identified a wide range of factors that facilitate effective implementation of strategic plans, including leadership; stakeholder/participant involvement; a common understanding of the vision, mission, strategic intent and strategy, based on clear, unifying goals and objectives; and, of course, effective communications. In the latter category, specific aspects of communications that were mentioned include documented requirements; clear priorities, issues, and plans; listening to everyone's ideas; leadership's articulation of employees' contribution; and a clear format for published products.

A large number of leadership factors were cited, including:

- Vision
- Follow through
- Commitment
- Resources
- Involvement/interest
- Buy-in
- Understanding
- Communication
- Implementation
- Attitude

This last item captured a variety of comments such as the assertion that implementation should not be just a "check-the-box" effort; that PMs should take a long-term approach, not day-to-day churn; that management should play a part in the development of strategic planning so that they will understand their roles, their employees' roles, and the importance of execution; and that pressure should be exerted from above to use the tools available to effectively implement these processes.

1

All the factors just mentioned aren't surprising, and are consistent with well-understood best practices in applying SP&M methodologies. However, a number of other factors were raised that also merit further consideration. These include (in no particular order):

- Ensuring proper training and leadership classes to retain a knowledgeable workforce;
- Positioning a full-time facilitator/in-house expert;
- Instilling continuity, including having a living document; persistency ("don't change halfway through"), transition into sustainment, continuity through leadership changes, and maintaining consistent direction;
- Having a good governance structure (objective owners, quarterly reviews);
- Ensuring appropriate, stable resources, including time to commit to planning and implementation, and funding;
- Taking the time to do a good job ("When done properly, strategic plans can be very effective, but most managers/leaders get impatient");
- Showing direct impact to participants, with incentives;
- Encouraging effective teamwork;
- Paying attention to cultural change, including frequent use of SP&M and constant monitoring and follow-up;
- Cultivating a practical attitude, including open mindedness and willingness to face the brutal facts;
- Seeking perspective, including understanding the value streams of the organization's products and services, and the global impacts, political climate, and funding associated with the effort;
- Establishing executable processes up front;

- Having a plan above you to lash up to;
- Integrating with other project management disciplines;
- Assessing direct measurable impact to the organization; and
- Making your customer successful.

Next, participants were asked to rate a number of commonly used SP&M tools and methodologies, and to identify other tools that they have found useful for SP&M. From this survey, the most useful tools (and the primary use to which they were put) were:

- Action plans, used to establish priorities and clarify expectations;
- Root cause analyses, used to establish priorities and lower cost;
- Mission/strategy mapping, used to align the organization;
- Brainstorming;
- Program analysis/assessment, used to establish priorities;
- Needs assessment, also used to establish priorities;
- Strengths, Weaknesses, Opportunities, and Threats (SWOT) analyses, used to establish priorities;
- Stakeholder interviews, used to clarify expectations; and
- Vision statements, used to clarify expectations and align the organization.

These "most useful" tools were highly rated (Likert 6 or 7 on a 1–7 scale) in over 50 percent of the responses.

1

For the respondents who gave the highest ratings to the usefulness of SP&M in improving program outcomes, the highest rated tools were:

- Program analysis/assessment, used to establish priorities and improve alignment;
- Needs assessment, also used to establish priorities and clarify expectations;
- Mission/strategy mapping, used to align the organization and establish priorities;
- SWOT analyses, used to establish priorities and clarify expectations; and
- Action plans, also used to establish priorities and clarify expectations.

Interestingly, some of the least useful tools were company proprietary software, force field analysis, and environmental scans. This last factor is somewhat confusing since reviews of the regulatory environment and reviews of industry trends (which would be included in an environmental scan) were more widely used. Perhaps the term "environmental scan" wasn't familiar to respondents. Further discussion with the community may clarify this ambiguity.

Other tools that were rated, but which fell somewhere in the middle on the usefulness reports, included scenario planning, Balanced Scorecard, use of process consultants, and use of industry experts/futurists.

Respondents also mentioned a wide range of other specific tools that they are using to facilitate SP&M in their organization (Table 1). These responses are listed in no particular order or grouping. DAU plans to further investigate these tools to understand which would be most appropriate to incorporate in structured SP&M training for wider use across the defense acquisition community.

TABLE 1. SP&M TOOLS BEING USED BY THE DEFENSE ACQUISITION COMMUNITY

- Business intelligence
- Dashboards
- Well-prepared offsites
- Discovery-Driven Plan/ Discovery-Driven Growth
- Army Strategic Management System
- Probability of Program Success (PoPS)
- Systems2Win, including LEAN and Six Sigma tools
- Continuous Process Improvement
- Objective risk-based threat/ issue assessments
- Analysis of Alternatives tool (PMT 350)
- 7- or 9-Step Standardize-Do-Check-Act (SDCA)
- X-matrix
- Winsight/Project
- QuickScore (Spyder Strategies)
- Capability Maturity Model Integration (CMMI)
- Quality Function Deployment
- Design of Experiments
- Bottom-to-top communication
- Logistics elements review and development
- Hoshin planning
- Risk Analysis
- Issue- or Action Item-based program management software
- Project Management tools, practices, and processes
- Contract negotiation consultants
- 8-Step Problem Solving
- Define, Measure, Analyze, Improve Control (DMAIC)
- Campaign Planning Process
- Plan of Action and Milestones (POAM)
- Assumption/strategic risk analysis (integrated with other project management disciplines)
- Objective assessment of value-added for various DoD acquisition processes
- Organizational climate survey
- Prerequisite Trees
- Conflict Diagrams
- Root-Cause analysis
- Voice-of-the-Customer feedback
- Business Case Analysis
- Theory of Constraints
- Integrated Computer Aided Manufacturing Definition for Function Modeling (IDEFO)
- Current Reality Trees/Maps
- Future Reality Trees/Maps
- Injection Maps
- Competency-based toolsets/planning processes (e.g., Lominger)

When survey participants were asked to identify the biggest roadblocks to effective SP&M, the top three were the lack of time, lack of management commitment, and lack of follow-up. Less pressing, but still notable roadblocks included lack of expertise, lack of funds, lack of training, and ineffective tools.

For the respondents who gave the highest ratings to the usefulness of SP&M in improving program outcomes, the lack of management commitment was the roadblock most often cited, followed closely by lack of time.

The respondents were also given the opportunity to identify other roadblocks to effective SP&M they have encountered, which are listed in Table 2 in no particular order or grouping.

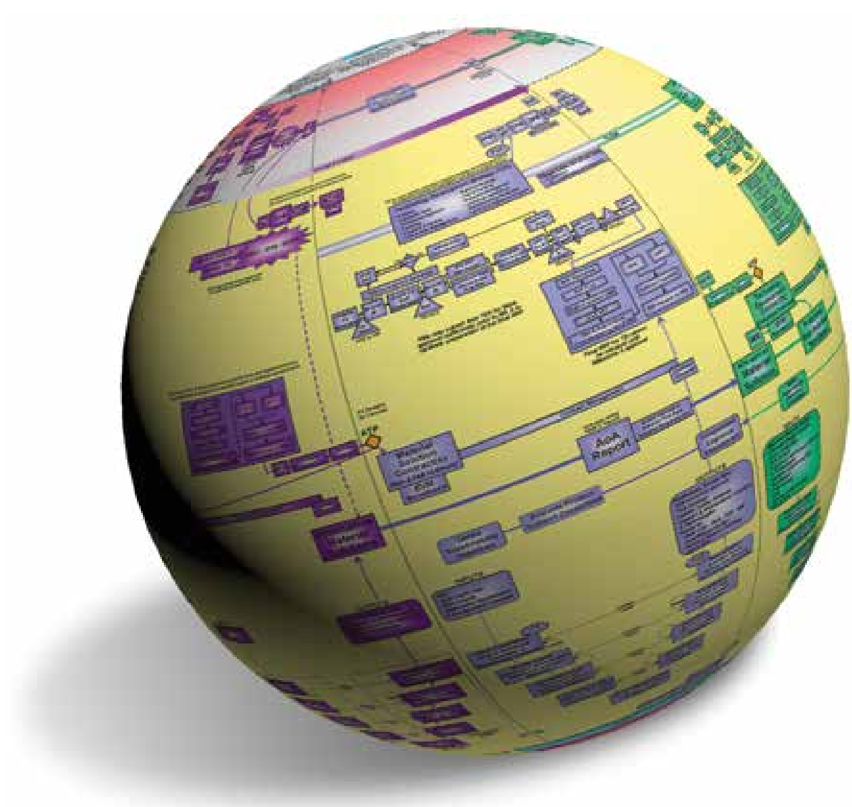

TABLE 2. ROADBLOCKS TO EFFECTIVE SP&M

- Ineffective metrics
- Senior leadership (PEO/PM) disagreement about strategy
- Lack of stakeholder/employee buy-in
- Lack of business and organizational management background and experience
- Lack of senior-level vision to require strategic planning
- Getting commitment from assigned personnel
- Lack of personnel trained in acquisition disciplines
- Poor communication
- Lack of cohesive vision
- Command attitude (crisis management, don't make waves, not invented here)
- Culture of "zero mistakes"
- Management distraction
- Unpredictable/erratic Congressional budgetary direction
- Contracting timelines
- Use of inappropriate models (e.g., aircraft in space acquisition)
- Jaded members of the organization (regarding strategic plans)
- Unrealistic timelines
- Working outside of "requirements"
- Mid-management reluctance to change (not "real work")
- Personnel commitment degradation due to Congressional attitudes; low morale
- Too many inefficient legacy processes
- Unforeseen external drivers that derail plans
- Inability to match time, expertise, and funds
- Inadequate internal controls
- Overwhelming burden of oversight and reporting
- Difficulty in tracking strategic improvement
- Competition among organizations to "be the solution"
- Constant reorganization (Navy)

Usefulness of specific resources for effective SP&M was also measured. The most useful resources were internal staff and the respondents' own personal research into SP&M; funding, communities of practice, and tool experts were also found to be somewhat useful. Least useful were external process consultants and external meeting facilitators. However, even for these less useful resources, about 20 percent of the responses indicated that they were very useful (Likert 6 or 7 on a 1–7 scale). In short, all these resources can be important for effective SP&M.

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For the respondents who gave the highest ratings to the usefulness of SP&M in improving program outcomes, the use of internal staff was cited much more often than the use of external help. This would seem to indicate that training our organic resources to conduct effective strategic planning and management would likely have more impact than relying on external consultants.

SP&M can be highly valuable to Department of Defense systems acquisition programs and organizations when employed by experienced practitioners and managers.

In this context, it is interesting that the great majority (69 percent) of respondents indicated that they plan to use SP&M tools and methodologies in the future, although two-thirds of this community have either no resources committed or are unaware of resources committed for future SP&M.

The survey also identified significant interest in additional training and education of SP&M topics. Two-thirds of the responders indicated interest in additional training in SP&M tools and processes, and over 75 percent would like to learn more about best SP&M practices for defense acquisition organizations and programs. The most often cited tools for which additional SP&M training was recommended were:

- Program analysis/assessment
- Needs assessment
- Mission/strategy mapping
- SWOT analyses
- Root cause analyses
- Balanced scorecard
- Stakeholder interviews

Acknowledgment

I would like to thank Donna Seligman and Shandy Arwood, who provided assistance with the survey and data analysis, and Lois Harper, who headed the research support team. I would also like to thank the survey respondents for the time expended in the completion of this survey.

Summary

The data collected in this analysis indicate that SP&M can be highly valuable to Department of Defense systems acquisition programs and organizations when employed by experienced practitioners and managers. Moreover, specific high-value activities, tools, processes, and practices have been identified, as have common roadblocks to effective SP&M. Clearly, the data reflect that for SP&M methods to be successful, acquisition organization leaders must understand the importance of their use. Moreover, tool use and process training are needed widely within the community, especially for senior leaders. From these observations, a conclusion can be drawn that implementation assistance can be very useful and should have significant payoff in terms of organizational effectiveness and program management success.

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Improving Program Success Through Systems Engineering Tools in Pre-Milestone B Acquisition Phase

Daniel Deitz, Timothy J. Eveleigh, Thomas H. Holzer, and Shahryar Sarkani

Today, programs are required to do more with less. With 70 percent of a system's life-cycle cost set at pre-Milestone B, the most significant cost savings potential is prior to Milestone B. Pre-Milestone B efforts are usually reduced to meet tight program schedules. This article proposes a new Systems Engineering Concept Tool and Method (SECTM) that uses genetic algorithms to quickly identify optimal solutions. Both are applied to unmanned undersea vehicle design to show process feasibility. The method increases the number of alternatives assessed, considers technology maturity risk, and incorporates systems engineering cost into the Analysis of Alternatives process. While not validated, the SECTM would enhance the likelihood of success for sufficiently resourced programs.

Image designed by Diane Fleischer »

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This article examines the importance of developing a robust Analysis of Alternatives (AoA) early in the concept phase of the acquisition program (prior to Milestone B) and the effects such development may have on program success. While current statutes require that program managers complete an AoA for all Acquisition Category (ACAT) programs, the quality of the AoA is the predominant indicator for program success and consists of more than just completing a study (Government Accountability Office [GAO], 2009a). In 2008, the Department of Defense (DoD) had 96 major defense acquisition programs, which experienced a cost growth of $296 billion and an average schedule delay of 22 months (GAO, 2009a). The GAO completed a study in 2009 where it identified one of the key causes for this cost and schedule growth as the mismatch between the requirements of the systems and the resources to provide them (GAO, 2009a). GAO further stated that programs enter the acquisition process with requirements that are not fully understood, cost and schedule estimates that are based on optimistic assumptions, and a lack of sufficient knowledge about technology, design, and manufacturing.

While SECTM cannot be validated until implemented by acquisition programs, it is expected to increase the likelihood of successful programs that, if sufficiently resourced, can deliver on time and on budget.

The DoD has a history of rushing programs into development or production that are not ready due to various program constraints. The Joint Strike Fighter was intended to produce an affordable aircraft, but ended up being the most expensive aircraft program in DoD with over $200 billion for 3,000 aircraft. GAO attributed a major factor for the cost overrun to the program's premature entry into the engineering, manufacturing, and development phase prior to the maturation of critical technologies (GAO, 2001). The Navy has entered into shipbuilding contracts without fully maturing component technologies, resulting in a 193 percent cost growth on Littoral Combat Ship 1 and a 52-month delay on Landing Platform Dock 17 (GAO, 2009b). This rush is not just on large ACAT I programs, but also on smaller ACAT programs (Pincus, 2012). The Navy Organic Airborne and Surface Influence Sweep (OASIS)

program just experienced a cost increase from $55 million to $135 million, with an 8-year delay in fielding. This system still has not met the requirement to continue operating after being hit by a shock wave from a mine or ordnance explosion (Pincus, 2012). The latest results from the last Department of Defense Inspector General (DoDIG) study indicated OASIS met only 65 percent of its shock requirement and would not work (DoDIG, 2012).

This article defines a new Systems Engineering Concept Tool and a five-step system engineering Method (SECTM) that we developed to increase the robustness of AoAs. We based the SECTM design on the finding from the GAO (2009a) study that examined 32 DoD programs, and the impacts that the quality of the AoA can have on program success. We applied SECTM to a UUV concept design to show the feasibility of implementing the process. SECTM includes a Systems Engineering Concept Tool based off genetic algorithms to quickly explore the design solution space. While SECTM cannot be validated until implemented by acquisition programs, it is expected to increase the likelihood of successful programs that, if sufficiently resourced, can deliver on time and on budget.

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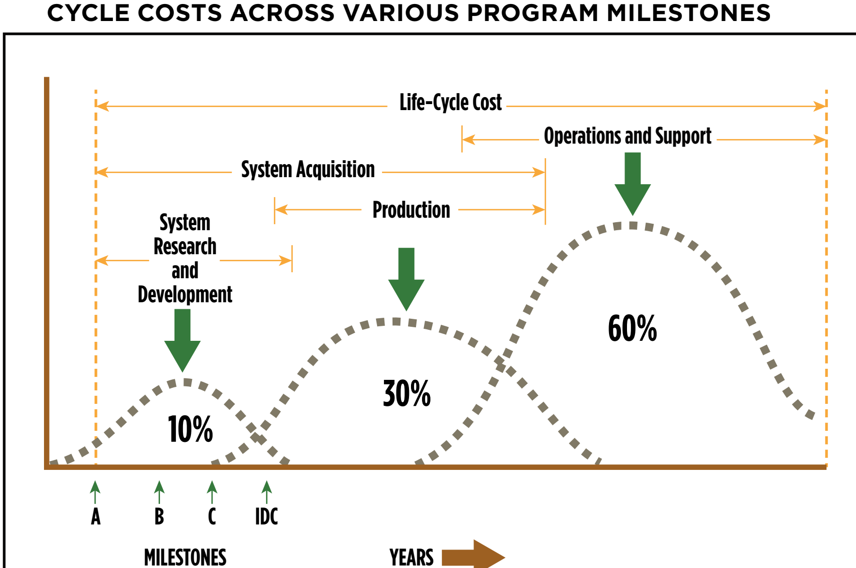
Importance of Early Information

Within the increasingly constrained fiscal environment in which the DoD must operate, program life-cycle cost control is especially important. All DoD programs, no matter which ACAT level is involved, follow a program path that has an impact on life-cycle costs. Smaller ACAT programs can streamline or skip minor steps, but the overall acquisition process is the same. The Defense Acquisition University has defined life-cycle cost across the various program milestones as shown in Figure 1 (Defense Systems Management College, 1990). Only 10 percent of the program's life-cycle cost is invested during the system's research and development phase up to the system's initial operational capability; however, this may be the most important 10 percent of the system's life-cycle cost. As this phase commits 70 percent of the program's life-cycle costs, focusing significant time and effort to assure that all alternatives are considered is very important.

FIGURE 1. DEFENSE ACQUISITION UNIVERSITY DEFINED LIFE-CYCLE COSTS ACROSS VARIOUS PROGRAM MILESTONES



Current Analysis of Alternatives

In today's environment, program managers are encouraged to move as quickly as possible to meet urgent operational requirements, replacement schedules, or to save time. Because the majority of the pre-Milestone B work is level of effort, shortening this effort is easier than shortening the design and fabrication work. While this approach may be appealing to many program managers and requirements officers, the acquisition efforts leading to Milestone B set the foundation for the program. The work in this phase defines the acquisition strategy and life-cycle cost.

In 2009, GAO analyzed 32 major defense acquisition program starts since fiscal year 2003. That analysis is summarized in Table 1 (GAO, 2009a).

TABLE 1. COMPARISON OF THE SCOPE OF ALTERNATIVES CONSIDERED WITH PROGRAM COST AND SCHEDULE GROWTH

		Number of programs with cost or schedule growth[a]	
Scope of alternatives[b]	**Low**	**Moderate**	**High**
No AoA conducted	7	0	3
AoA included broad scope of alternatives	7	1	1
AoA included narrow scope of alternatives	4	1	8

Source: GAO.

[a] Cost growth: High = 25 percent or greater growth in development cost (or procurement costs for nondevelopmental programs) from initial baseline to current estimates, Moderate = 10–24 percent growth in development cost (or procurement costs for nondevelopmental programs) from initial baseline to current estimates, Low = less than 10 percent growth in development cost (or procurement costs for nondevelopmental programs) from initial baseline to current estimates.

Schedule growth: High = greater than 12-month delay for the initial operational capability date or acquisition cycle, Moderate = 7- to 12-month delay for the initial operational capability date or acquisition cycle, Low = less than 7-month delay for the initial operational capability date or acquisition cycle.

[b] Narrow scope of alternatives = 2–5 alternative within one concept; broad scope of alternatives = 8–26 alternatives within one concept, or alternatives within multiple concepts.

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Of the 32 major DoD acquisition programs, 10 programs did not complete a formal AoA. For at least seven of those, this may have been appropriate since they were modernization or evolutionary programs. The *Defense Acquisition Guide*, which states that an AoA should focus on the end-state solution, contains recommendations on a single development or evolutionary development path (Defense Acquisition University, 2012). The Milestone Decision Authority can waive the requirement for a new AoA for incremental or modernization efforts included in previous analyses. The Navy Standard Missile SM6 is an example of an evolutionary acquisition program where block increments were used to incrementally reach the final capability, thereby negating the necessity for an AoA. Thirteen major acquisition programs conducted a narrow scope AoA where over 60 percent of the programs experienced significant cost or schedule growth. Nine major acquisition programs conducted a broad scope AoA where only one of these programs experienced a significant cost or schedule growth. This GAO (2009a) study showed that broader scope AoAs had less cost and schedule overruns.

Because the majority of the pre-Milestone B work is level of effort, shortening this effort is easier than shortening the design and fabrication work.

Let us highlight one program's AoA process. The Air Force needed to replace its KC-135 tanker. This was a high-visibility major ACAT I defense program for the Air Force. The KC-135 provided 80 percent of U.S. air refueling capability that enabled airpower to be deployed and sustained overseas in a timely manner. The fleet of KC-135s was reaching 50 years of age and becoming increasingly costly to maintain and operate. The replacement program for these aircraft was expected to be close to $200 billion (RAND, 2006), and 6 months were allocated for the AoA.

The KC-135 AoA was required to study the amount of fuel the aircraft could supply along with the times and locations in a set of mission scenarios (RAND, 2006). The AoA met these criteria through analyzing four major aircraft classes and seven different methods to procure those classes. However, the AoA was focused on only one major objective: life-cycle cost. The AoA assumed that all threshold requirements must be met, so no analysis was conducted to see if any single requirement was

driving the cost. In addition, the AoA did not look at the technology risk of the program to predict the level of uncertainty that can drive program overruns late in the design.

The GAO (2009a) report found that narrowing the AoA scope to life-cycle cost did not enable the identification of the most promising alternative, and reducing the AoA schedule did not allow enough time to complete a thorough analysis. The GAO study recommended that DoD develop guidance for conducting robust AoAs to adequately select an alternative (GAO, 2009a).

Systems Engineering in the Pre-Milestone B Acquisition Phase

Program managers and resource sponsors are under increasing pressure to perform at a higher level with less resources. It appears unlikely that increasing either the timeline or the cost of conducting an AoA is an option. We propose to use our SECTM in the AoA process to thoroughly evaluate additional alternatives in the same AoA timeline.

The systems that DoD acquires have become more complicated, and quantifying the effect that each requirement has on these systems is becoming increasingly difficult. As the DoD strives to adopt more commercial practices, it will need to adjust its acquisition processes. Unlike the DoD, the commercial industry focuses on the market and the price point to enter into that market. Most commercial industry program/project managers attempt to find the best value for the customer by providing the most capability for a set price. In today's shrinking defense budget, a more commercial strategy may be needed to keep the same force levels and capability despite reduced funding. According to Navy Admiral Jonathan Greenert (Chief of Naval Operations, 2012):

> We can no longer afford, strategically or fiscally, to let the perfect be the enemy of the good—or the good enough—when it comes to critical war fighting capability. (p. 7)

Systems engineering provides the rigor needed to handle the increasing complexity of today's DoD systems. We are moving from lowest cost for a set threshold performance to simultaneously minimizing or maximizing multiple objectives like minimizing cost, maximizing performance, and minimizing program risk. In multiple-objective analysis,

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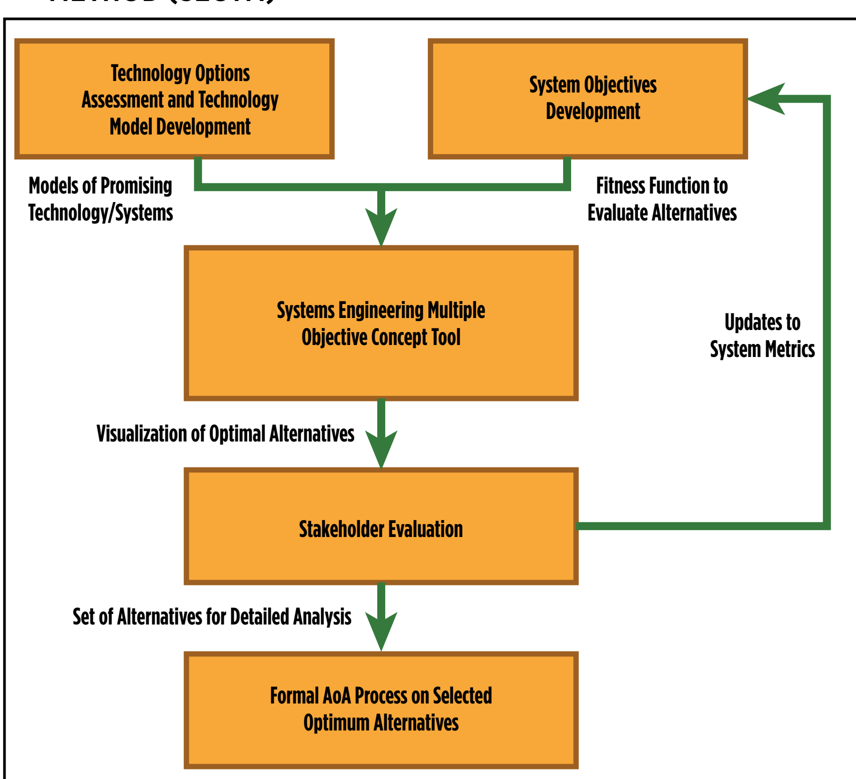
multiple solutions exist that are each optimal, since they are at least as good as any other solution for some weighted combination of the multiple objectives. For that reason, these solutions are referred to as nondominated, as they each have no other solution that dominates for at least one weighted combination of the objectives. The set of all nondominated solutions is referred to as the Pareto front. Figure 2 is an example of a Pareto or nondominated solution where the design solutions are shown in orange and the optimal solutions form a line shown in green (Brown, 2003). In a Pareto optimal designed system, the design can trade off cost versus risk to find an optimal solution. As parameters are varied in one optimal solution, they create other optimal solutions if the solution improves in meeting at least one objective. Therefore, for a solution to be optimum, it can only decrease cost to the point where it has a negative effect on performance or program risk.

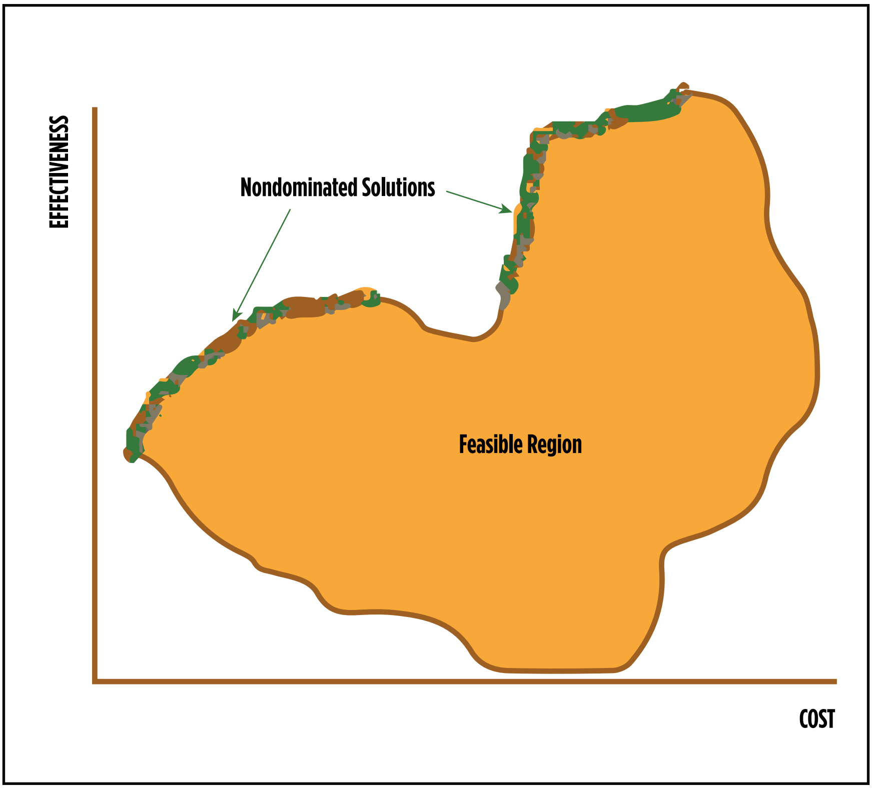
FIGURE 2. SYSTEMS ENGINEERING CONCEPT TOOL AND METHOD (SECTM)



Using multiple-objective analysis, we developed a new tool and designed a method (SECTM) to address GAO's recommendation that DoD AoAs need to investigate a broader scope of alternatives to increase their robustness (GAO, 2009a). The SECTM increases breadth of the alternatives considered, investigates program risk based on technology selections, and addresses systems engineering complexity in the cost estimate, as shown in Figure 3. The proposed approach assesses the technologies, defines the system metrics, provides a tool to evaluate the alternatives, and can provide the stakeholders with an assessment of optimal alternatives. The alternatives that appear to be within the available resources could proceed to the formal DoD AoA process.

The steps in our proposed process are detailed in the following discussion.

FIGURE 3. EXAMPLE OF A PARETO OR NONDOMINATED SOLUTION



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Step One—Assess Availability of Current Technology

The first step in the proposed approach is to assess the current technology available and develop models of those key technologies or subsystems. This will allow a wide net to be cast for investigating technologies, typically using Technology Readiness Levels (TRL) 1–9. In 2001, the Deputy Under Secretary of Defense for Science and Technology endorsed the use of TRL in new major acquisition programs. DoD Instruction (DoDI) 5000.02 describes TRLs from a systems perspective and states that they are to be used for both hardware and software (DoD, 2008). While to date, they have been used in the criteria for gate reviews, they do not fold in program risk. Subsystem concept models should be created to represent system performance, cost, and risk, and include TRL evaluation.

The cost of doing systems engineering is becoming a significant cost factor due to the increased complexity of today's systems.

Step Two—Define Objectives for Alternatives

The second step, which can occur in parallel to step 1, is the definition of high-level objectives (and associated metrics) for the alternatives. For robustness, there should be at least three primary objectives considered: technical performance, cost, and risk (GAO, 2001). These objectives will be used to rank the different alternatives and provide recommendations on the set of optimal solutions in the next step.

Technical performance and cost objectives are part of the standard AoA process and should continue to be defined. In addition to cost and performance, we recommend using Technology Maturity Risk as a new objective. The GAO (2009a) report states that inadequate technology maturity is a key factor in program cost and schedule overruns. The time has come to explicitly consider Technology Maturity Risk in the AoA to increase program success.

Researchers at the University of Southern California Center for Software Engineering have proposed an approach that includes technology maturity risk. They report that TRL maturity has both positive and negative aspects. Higher, more mature technologies can have a greater

TABLE 2. TECHNOLOGY MATURITY RISK

Viewpoint	Very Low	Low	Nominal	High	Very High
Lack of Maturity	Technology proven and widely used throughout industry	Proven through actual use and ready for widespread adoption	Proven on pilot projects and ready to roll-out for production jobs	Ready for pilot use	Still in the laboratory
Lack of Readiness	Mission proven (TRL 9)	Concept qualified (TRL 8)	Concept has been demonstrated (TRL 7)	Proof of concept validated (TRL 5 & 6)	Concept defined (TRL 3)
Obsolescence	(Obsolescence not an issue)	(Obsolescence not an issue)	Technology is the state-of-the-practice; emerging technology could compete in future	Technology is stale; new and better technology is on the horizon in the near-term	Technology is outdated and use should be avoided in new systems; spare parts supply is scarce
Cost Multiplier	0.68	0.82	1.0	1.32	1.75

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risk of obsolescence or the possibility of a leap-ahead technology during the life of the DoD system. Lower, less mature technologies have greater development cost and schedule risk. These researchers have proposed a new Technology Maturity Risk function based on the TRL of a technology, the maturity of the technology in a system, and the risk of obsolescence. While Technology Maturity Risk has been considered in the past, Valerdi developed a new model that links the Technology Maturity Risk to a programmatic cost (Valerdi, Boehm, & Reifer, 2003). From Valerdi's study, which included efforts of over 40 systems engineering experts, this Technology Maturity Risk has also been associated with a program cost impact. Table 2 shows the rating scale for Technology Maturity Risk (Valerdi & Kohl, 2004).

Many programs underestimate the cost of the large systems engineering effort required to develop complex systems. Therefore, in addition to the life-cycle cost models of the individual systems (aircraft, ship, vehicle, weapons, information technology, etc.), the cost models need to consider the systems engineering cost. While advocating no particular cost modeling tool, the authors surmise that, to properly determine life-cycle costs, systems engineering costs must be considered in the life-cycle cost calculation. In 2003, Valerdi developed the Constructive Systems Engineering Cost Model (COSYSMO) for the purpose of estimating the systems engineering effort needed for large complex systems (Valerdi, Boehm, & Reifer, 2003). His analysis is based on four categories: product, platform, personnel, and project (with technology risk being a driver). With assistance from the International Council on Systems Engineering, the COSYSMO model has been validated with industrial partners while new lessons learned are continually incorporated (Valerdi, Rieff, Roddler, & Wheaton, 2007). The cost of doing systems engineering is becoming a significant cost factor due to the increased complexity of today's systems.

Step Three—Apply a Systems Engineering Concept Tool

The heart of SECTM is our Systems Engineering Concept Tool. The subsystems models from step 1 and the objectives from step 2 feed our Systems Engineering Concept Tool. We recommend that a genetic algorithm solver (see further discussion) be used because the user can select the number of alternatives to be considered, and genetic algorithms provide a good estimate of the optimal solution set. For complex systems with 10 or more critical design parameters, the number of different solutions can range from 10 to 100 billion, which is far too many to

investigate. A genetic algorithm solver quickly defines the solution space and provides a near-optimal solution set in a small number of iterations (Deb, 2001). A classical optimization problem would compare each possible solution pairwise, for which there may be 10 billion comparisons. Genetic algorithms can provide a good estimation of the optimal solutions with a population size as small as 100 and converge as quickly as 10 generations from the results of the UUV example described later. Deb (2001), a recognized expert in genetic algorithms, states that genetic algorithms have tremendous advantage over classical search techniques because genetic algorithms move the entire optimal population toward the optimal solutions instead of a single solution.

Genetic algorithms were developed to imitate the processes that evolve in living beings, and the algorithms allow the designs to evolve each generation to better meet the identified objectives.

Genetic algorithms were developed to imitate the processes that evolve in living beings, and the algorithms allow the designs to evolve each generation to better meet the identified objectives. Even if they do not use this formal methodology, designs typically evolve just with trial and error (Eddy & Lewis, 2001). The heart of genetic algorithm research began with Schaffer in the 1980s. Now, many genetic algorithms are available that can be applied to this problem due to prior research (Schaffer & Grefenstette,1985; Zitzler, Deb, & Thiele, 2000; Horn, 1997). A few common algorithms include the Vector Evaluated Genetic Algorithm (VEGA), Nondominated Sorting Genetic Algorithm (NSGA II), and Niched Pareto Genetic Algorithm II (NPGA) (Zitzler, Deb, & Thiele, 2000). VEGA, one of the first Pareto genetic algorithms from the 1980s, works by assigning a randomly selected single objective to each member of the population. NPGA was developed by Horn and Nafpliotis in 1993, and improved on the selection process determining the dominance of randomly selected groups of individuals in the population (Coello Coello, 2000). NSGA II was developed from work by Srinivas and Deb (1994) in 2000, and improved upon the basic genetic algorithm by sorting the population in multiple-level solutions, starting with the nondominated and binning them into levels of domination until

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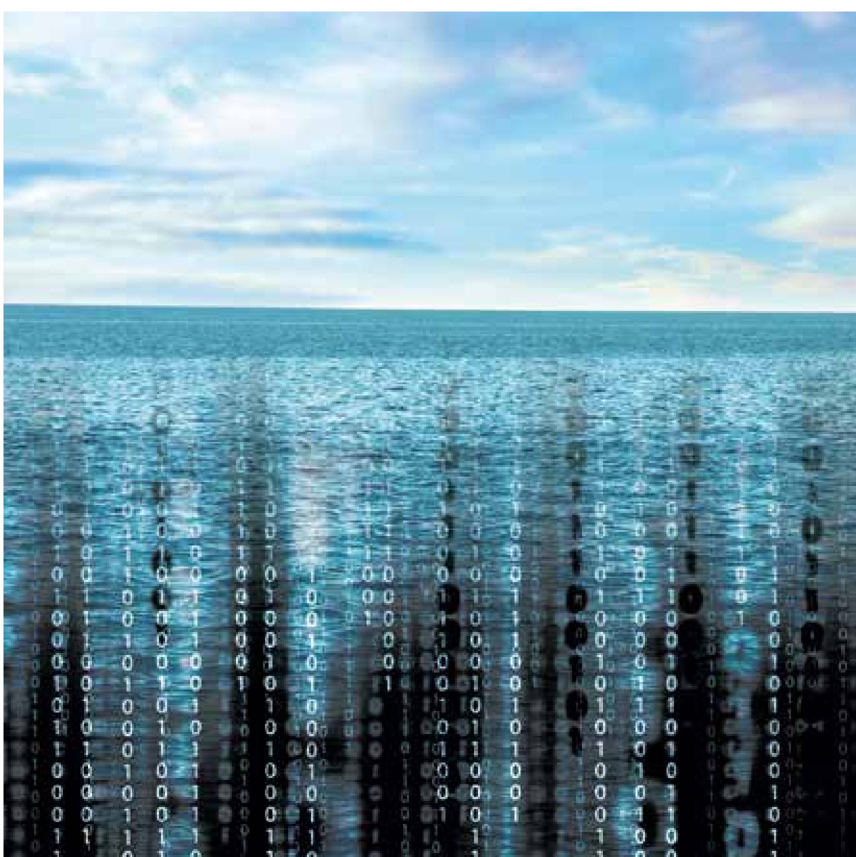
all solutions are binned. The level of domination is used to modify the fitness of individuals. This allows for quick and computationally efficient algorithms compared to other methods (Coello Coello, 2000), which is why we selected NSGA II for this research. Genetic algorithms have been used to solve many complex problems, especially in aircraft and shipbuilding where many objectives compete with each other. Figure 2 shows an example of Pareto front trading off effectiveness or performance versus cost. The feasible region is the large number of possible alternatives in orange. The nondominated solutions are the set of optimal solutions. For multiple-objective problems, two solutions are possible: one dominates (or is better than the other) or nondominated (each solution is equally good as one another). Defined by Goldberg (1989), a solution is considered nondominated when an objective cannot be increased without reducing the other objectives. In complex systems, rarely is there one optimal solution, but rather a set of optimal solutions. The stakeholders



need to make the final choices between optimal solutions that best meet their needs. The goal of our Systems Engineering Concept Tool is to identify those optimal solutions.

The Systems Engineering Concept Tool should, at a minimum, include three primary objectives: technical performance, cost, and risk. Many AoAs today only consider the cost to meet the threshold requirement, whereas SECTM would allow key performance parameters to be separate objectives, and cost and risk could be traded among those key parameters.

Step Four—Presentation of Optimal Alternatives to Stakeholders

The fourth step in the proposed process shown in Figure 3 is to present the optimal alternatives developed from the Systems Engineering Concept Tool to the stakeholders. Since one optimal solution is rarely applicable in complex systems, an Executive Steering Group (ESG) should narrow the set of optimal solutions to those that fall within the resources available and the program constraints. Through the use of tradeoffs, SECTM will provide a set of optimal solutions that meet the metrics defined in step 2. Since these solutions are equal mathematically, the ESG needs to identify or narrow the "best solutions" dependent on preferences and experience (Faulkenberg & Wiecek, 2010). These narrowed solutions should then undergo a detailed analysis by subject matter experts. The ESG can also decide to change the metrics to refine this analysis if none of the alternatives are appropriate.

Step Five—Detailed Analysis (Similar to DoD's AoA Process)

The last step is to take the narrowed set of optimal alternatives and complete a detailed analysis of each alternative. This step is similar to the DoD AoA process, which uses a set of subject matter experts and increased fidelity models and simulations to determine and subsequently recommend the best alternatives. The analysis in step 5 will use high-fidelity physics models that are significantly more detailed than the subsystem concept models used in step 1.

Summary of the Five Steps

The developed methodology described in the preceding 5 steps is anticipated to increase the robustness of the DoD pre-Milestone B Phase AoA by:

- Widening the solution space investigated within the time and personnel constraints;
- Incorporating the Technology Maturity Risk; and
- Incorporating the cost to mitigate Technology Maturity Risk and the level of systems engineering needed for complex DoD programs.

Application of SECTM to Unmanned Systems Concepts

In this section we demonstrate the use of SECTM on unmanned systems that have a strong appeal in the DoD environment. Unmanned systems take the DoD's most valuable asset—its personnel—and remove them from dull, dirty, and dangerous tasks. These systems demonstrably reduce the forward deployments of our military personnel, thereby increasing the quality of life for our soldiers and their families.

Unmanned aerial vehicles (UAV) have been used for many years with high success in the war against terrorism. Secretary of the Navy Ray Mabus stated his priority in maintaining the competitive edge by moving beyond pilotless UAVs to fielding unmanned undersea vehicles (UUV), as well as surface vehicles (Mabus, 2010). UUVs will provide a new capability without significant experience or analysis to bound AoA scope. Since UUVs may be the next big acquisition of unmanned systems, they are a good test case for SECTM. The following discussion reapplies the steps defined earlier using an analysis of UUV designs as an example.

Step One—Assess Availability of Current Technology

The first step in applying SECTM was to analyze the UUV subsystems and to determine the critical technologies in each subsystem. Subsystem models were created from core hydrodynamic texts and UUV literature from Massachusetts Institute of Technology and Southampton Universities (Furlong, McPhail, & Stevenson, 2007). We developed a

basic UUV cost model using the Naval Sea Systems Command cost estimation handbook, and adapting a submarine cost model and systems engineering cost models (Valerdi, Boehm, & Reifer, 2003).

We identified critical technologies for achieving endurance that were based on experience with the Autosub UUV (Furlong, McPhail, & Stevenson, 2007) being designed for an endurance of 5,000 meters and buoyancy-driven UUVs. For simplicity of this example, the two driving technologies are the energy density of the primary power system and the hotel load (for example heating, computing, power distribution). Most current UUV systems use batteries, which are a high TRL (mature), but low-energy density. However, high-energy density power systems like fuel cells and combustors are being developed and show promise at low TRLs. We completed a market survey to look at the different battery technologies and their energy density as a function of TRL. Hotel power was linked to one primary technology—computer processors. We used current quad-core processors as the standard processor at TRL 8. New gaming and cell core processors are being developed that have the potential to reduce the processing power by a factor of four, but these are only at TRL 3. Once again, we completed a market survey and created a model to link processing power with a TRL.

Step Two—Define Objectives for Alternatives

Step Two defines the objectives for the system Pareto analysis. We used the 2004 Navy UUV Master Plan as a guiding document to determine the UUV design objectives (Department of the Navy, 2004). The first objective was to maximize the endurance or range of a UUV to be able to perform Navy missions like mine warfare and intelligence, surveillance, and reconnaissance. The second design objective was to minimize the UUV's volume. This is important for integration of the UUV onto existing Navy platforms since larger UUVs may not fit on many Navy ships. The third and fourth objectives were cost and technology risk.

Figure 4 illustrates the 10 different parameters we considered in this UUV analysis and links those parameters to each objective.

FIGURE 4. SECTM OBJECTIVES AND SYSTEM PARAMETERS

Four design objectives to optimize:

Range = f (l, d, B, V, P_H, η_m, η_p) Maximize

Volume = f (l, d, B, P_H, D, V_M, σ) Minimize

Cost = f (l, d, D, B, TRLs) Minimize

Technology Risk = f (TRLs) Minimize

Design Parameters for UUVs:

1. Length (l)
2. Diameter (d)
3. Energy Density (B)
4. Foam Specific Gravity (σ)
5. Velocity (V)
6. Maximum Velocity (V_M)
7. Hotel Power (P_H)
8. Motor Efficiency (η_m)
9. Propulsion Efficiency (η_p)
10. Depth (D)

Early communication with stakeholders on potential alternatives can facilitate a better understanding of the requirements.

Step Three—Apply a Systems Engineering Concept Tool

We chose the NSGA-II genetic algorithm developed by Deb (Deb, Pratap, Agarwal, & Meryarivan, 2002) for our basic genetic algorithm solver because of this algorithm's computational efficiency. NSGA-II's computational efficiency can be approximated by the formula: $f(M{*}N^2)$ as opposed to other sorting algorithms, which use $f(M{*}N^3)$ where M is the number of objectives and N is the genetic population size. For the UUV example where $M = 3$ and $N = 100$, NSGA-II saved 2,970,000 computations. We programmed equations for each of the design objectives into Matrix Laboratory, or MATLAB programming language using the NSGA-II algorithm for the optimization.

Since the population size is variable, it can be selected by the users. Increased population size provides more points on the Pareto front to better identify design trends. However, increased population size will square the number of computations required.

For this example, there are 10 basic design parameters (*r*). For simplification, if each design parameter had only 10 different applicable values (*n*), then through pairwise comparison:

Estimated number of comparison = n^r

For this example, $n = 10$ and $r = 10$, which is 10 billion combinations that would have to be analyzed. This is far too many to accomplish in just a few months; however, the use of a genetic algorithm solver reduces the number of processes significantly. The genetic solver starts with random solutions. Those solutions that have a higher match to the objectives are selected for regeneration and combined together to create a new generation. This process is continued and mimics the way living species survive and adapt to the environment. Genetic algorithms usually can converge in 10 generations; therefore, the amount of calculation needed is the population size times the number of generations:

Number of designs: population x *generations* = 100 x 10 = 1,000

The results of this application show that for the UUV design discussed here, which is fairly simple compared to many DoD systems, the solution space of 10 billion different design combinations can be approximated by a population size of 10 or 100 with less than 1,000 design iterations using the SECTM. SECTM is a very efficient way to determine a set of optimal alternatives to present to the stakeholders.

Early communication with stakeholders on potential alternatives can facilitate a better understanding of the requirements. Today's systems are so complex and highly integrated, that it is impossible to understand the large impacts that small changes can make without the use of analysis tools. SECTM provides a visualization of the tradeoffs of risk, cost, and technical performance. These tradeoffs are very important to the success of the program. Using current practices, stakeholders are not presented with enough data to make good decisions. Steps 4 and 5 were not completed in this example as they feed the DoD AoA process and were not needed to show the feasibility of the SECTM.

2

Conclusions

In today's reduced budget and constrained fiscal environment, making acquisition decisions that provide the best value to the nation's armed forces and the DoD is extremely important. Over 70 percent of a system's life-cycle cost is determined by Milestone B; therefore, the largest impact can be made during these early program stages. Unfortunately, this is where a large majority of programs streamline, reduce, or cut activities to save time and funding. Out of 32 programs reviewed by the GAO (2009a), 60 percent of the programs that completed limited scope in their AoAs experienced significant cost and/or schedule overruns compared to less than 10 percent in those programs that completed a robust AoA.

Applying the SECTM in the pre-Milestone B Acquisition Phase is an option to increase the AoA's robustness without significantly increasing cost or time. Current processes use a team of experts to analyze a few predetermined alternatives (three to 10 for a typical acquisition program) and primarily conduct interviews to make subjective analyses. This article proposed a SECTM to be used in the AoA process to help determine or down-select the few alternatives that are investigated in depth by an AoA team. When we applied our SECTM to a UUV, we were able to reduce 10 billion design combinations to a set of only a few optimal solutions. This initial systems engineering step can be done rapidly using modeling and simulation tools, and by using the engineering process to down-select the alternatives instead of a steering group committee process.

This article also presented the importance of the pre-Milestone B Acquisition Phase in setting the foundation for the success of the program. This methodology presented a way to increase the robustness of the alternatives considered in pre-Milestone B acquisition documentation (primarily AoAs) and incorporates the following new aspects:

- Widening the solution space investigated within the time and personnel constraints;
- Incorporating the Technology Maturity Risk; and
- Incorporating the cost to mitigate Technology Maturity Risk and the level of systems engineering for complex DoD programs.

While pre-Milestone B efforts only account for less than 10 percent of the total life-cycle cost, they are the most important 10 percent of funding because they set the acquisition program on a sound foundation and business case. Errors in this phase cost between three and 10 times more to fix in later phases. The GAO recommended to the DoD that new criteria should be set for execution of AoAs, with the DoD agreeing to the recommendation. The approach proposed in this article is a way to increase the robustness of DoD's AoAs.

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Time Is Money

Roy L. Wood

Program managers typically focus on controlling costs and delivering a quality product. The acquisition stool's third leg—program schedule—appears to be a resource that can be slipped to accommodate unstable funding or technical difficulties. Despite studies linking high program cost and long schedules, few major defense acquisition programs are completed in less than a decade. Programs with longer schedules experience further schedule slips, exacerbating the problem. This article is based on research presented at the 2012 Naval Postgraduate School's 9th Annual Research Symposium. It includes a review of the extant literature on cost and schedule relationships, presents analysis of a survey of program manager perceptions and master schedule usage, and examines why schedules may be problematic to acquisition success.

Image designed by Diane Fleischer »


JULY
FULL MOON
TUESDAY
WEDNESDAY

Program success is traditionally measured by cost, schedule, and performance. When issues arise, trade-offs between these three are made; conventional wisdom, however, says the program manager (PM) can generally preserve only two of the three. For example, if current budgets are cut, then programs are forced either to give up some "bells and whistles" in performance, or lower the spend rate and stretch out the program schedule. If the program schedule is delayed for reasons such as lagging technology readiness or testing failures, then program costs will rise or the scope of the program's content will have to be sacrificed.

When making such trade-offs, reasonably good tools and techniques are available for estimating cost impacts and performance trades are usually understandable. However, when it comes to program schedules, trade-offs can be much less clear and the impacts more difficult to determine. "Working harder" or placing more "management emphasis" on an area are often viewed as ways to improve performance and "compress" schedules to remain on track. These ideas can lead to an overly optimistic attitude that, unlike money, time is somehow elastic and forgiving. This also leads to a skewed perception about the value of program time in the future versus the present. Resource problems in the near term are often "solved" by pushing work into the future, moving milestones forward while keeping the program end date static, while simultaneously compressing all the activities in between. This forces activities to become more concurrent and increases the complexity of coordinating and synchronizing program activities.

While most of us have heard the truism that "time is money," little evidence has emerged that PMs perceive aggressively managing time and schedules can help control costs.

Purpose

This article explores the relationship between program time and cost. While most of us have heard the truism that "time is money," little evidence has emerged that PMs perceive aggressively managing time and schedules can help control costs. As an exploratory effort, this research examined the literature on program scheduling, reasons program schedules were

not adhered to, and the relationship of program schedules to cost and program performance. Using a survey of 73 PMs attending senior courses at the Defense Acquisition University in February 2012, this article also examines PM uses and attitudes toward their own program schedules.

Length of a Program Contributes to Program Cost

The Packard Commission noted in 1986 that, "an unreasonably long acquisition cycle . . . is a central problem from which most other acquisition problems stem" (p. 8). Echoing this sentiment 20 years later, the Defense Acquisition Performance Assessment report recommended that, instead of waiting decades for 100 percent performance, programs be held to a "time-certain development" period of 6 years from the initial milestone (MS-A) to delivery of a militarily useful capability (Kadish, 2006, p. 12). The report enumerates some of the benefits of shorter development cycles:

- Operators with a basic capability in hand would gain a better understanding of full requirements to be inserted in future increments.

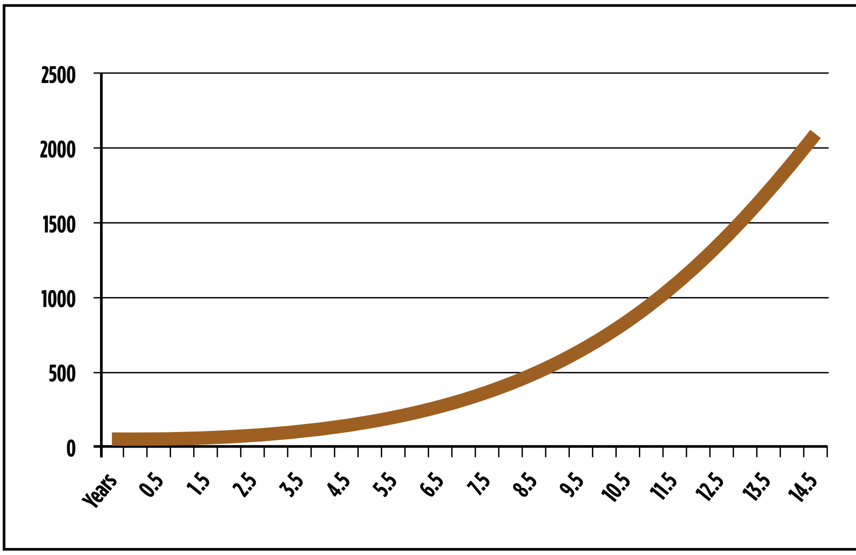
- Technology in the initial design would be at a higher readiness level, and would mature during the period between first deliveries and subsequent increments.

- New requirements and technologies would be intentionally inserted in later increments, removing the temptation to perturb the current development and adding stability to the acquisition.

- Reducing time in development would also help add funding stability across the entire program portfolio (Kadish, 2006, pp. 12–13).

In a dissertation study at the Massachusetts Institute of Technology of 154 defense projects, McNutt (1998) found that cost increased on a 4th power scale with development time. Figure 1 shows a derivation of McNutt's "best fit" power relationship on a linear plot. One can observe that the "knee in the curve" where costs begin to escalate significantly is around 6.5 years, indicating that costs for programs with schedules that extend beyond this point risk quickly becoming unaffordable.

FIGURE 1. DEVELOPMENT COST VERSUS TIME (LINEAR SCALE FOR CLARITY)



More recently, the Under Secretary of Defense for Acquisition, Technology and Logistics issued an update—*Better Buying Power 2.0*—that recognizes, and proposes to reduce, some of the factors that increase program development (Kendall, 2012). According to the memorandum, these include "oversight activities, funding stability, contracting lead time, requirements processes, technical complexity, use of risk reduction factors, and testing requirements" (p. 5). Some of those factors are examined in this article.

Complex Technical Requirements

A number of reasons may explain why the length of a program impacts its cost so dramatically. First, a longer schedule may be an acknowledgement of complex technological requirements that contribute to a program's developmental challenges. Programs like the F-35 Joint Strike Fighter or the DDG-1000 naval destroyer with substantial capability needs, advanced technology, unique features, or with significant integration or interdependencies with other programs, can be expected from the outset to take longer to develop, cost more, and have greater risk.

Evolving requirements and technology advancements. Programs with long timelines may also be subject to more requirements changes as threats and technologies evolve over time. As new threats

emerge during a program's development, there would be a need to try to address those threats by adding or refining the delivered system's capabilities.

Requirements changes during a program's lifetime can have substantial impact on schedule and cost. In a recent Center for Strategic and International Studies analysis, $37 billion of cost overruns in the major defense acquisition program portfolio are linked to schedule, and the report notes that defense contractors cite requirements changes late in a program as a major cause of schedule impacts (Berteau, Hofbauer, Sanders, & Ben-Ari, 2010).

Requirements changes during a program's lifetime can have substantial impact on schedule and cost.

Similarly, a recent industry white paper noted, "frequent and 'inside lead time' changes to program requirements and production schedules are major obstacles to successful cost and schedule attainment for most aerospace and defense programs" (Archstone Consulting, 2012). This assertion is backed up by the 2008 Government Accountability Office (GAO) analysis of defense weapons systems, which states that "63 percent of the programs we received data from had requirements changes after system development began. These programs encountered cost increases of 72 percent, while costs grew by 11 percent among those programs that did not change requirements" (p. 5).

When requirements changes occur during development, replanning and rework follow. New requirements must be flowed down as allocated functions via the systems engineering process. This becomes particularly challenging after Critical Design Review when a system's baseline is approved and the system is deemed ready to proceed to fabrication, demonstration, and test. Any new requirements must be engineered and integrated as well as possible into existing program plans. This adds complexity and takes time and care. Drawings and specifications must be revised, schedules and task budgets altered, test plans modified, and resources allocated or shifted to attend to new or modified tasks. In almost any conceivable circumstance, wasted prior effort will be scrapped and rework will be required to accommodate new changes, exacerbating the delay and disruption created by the new requirements.

Also, given the relatively few new program starts, the temptation is ever present for requirements managers and technologists to demand more capabilities in each new program. The need to meet forecasted future threats can also drive an appetite among users toward ever greater technical capabilities. Stressing requirements for the Air Force's fifth-generation fighter, the F-22 Raptor, for example, included stealthy titanium and composite structure, advanced avionics, active-array radar, supersonic cruise, and other enabling technologies. Likewise, the Navy's Zumwalt-class destroyer included requirements for reduced crew size, advanced active-array radar, integrated power system, electric drive, stealthy hull, integrated superstructure, 155 mm gun, and peripheral launching system. Many of these technologies were developed and matured concurrently during the program engineering and manufacturing development phases (Francis, 2005; GAO, 1998).

Schedule and cost uncertainty are high for new technology development, but this uncertainty becomes a substantial risk when overlaid on program milestones that depend upon successful delivery of the technology to support testing and fielding a new system. When several new technology developments are ongoing, as in the case of the F-22 and the Zumwalt destroyer, this uncertainty multiplies, and orchestration of technology insertion becomes extremely challenging. It should be of little surprise that both these programs delivered substantially late and over budget (Bolkcom, 2009; O'Rourke, 2012).

Budget churn. Unstable funding has often been blamed for program schedule and cost issues. Langbein (2004) cites three different types of funding instability that impact programs. The first is perhaps the most obvious—quantity of dollars. These are programs with insufficient total funding to perform the required tasks to deliver the system. Underfunded programs can be caused by poor cost estimating for the funding that is needed by the program, unforeseen and unbudgeted changes, or overly optimistic cost targets. In defense acquisition, two other, less obvious pitfalls—"color" of money and timing of money—can create program instability and schedule problems.

In every program, defense managers must break down total funding into its constituent functions and categories of funding for specific portions of the program. Research and development, procurement, operations and maintenance, shipbuilding and conversion, and other "colors" of money must be appropriately aligned to fund the associated

tasks in the program. At times, a program may have sufficient overall funding, but an incorrect allocation within the colors of money. The PM may find shortfalls in some areas and surpluses in others, but not have the authority to move the Congressionally appropriated dollars from one account to another. These shortfalls can stop activities in parts of the program and create overall delays. Timing of funding can also create similar problems. Program budgets are closely aligned with planned work in any given year. If challenges or opportunities arise within the year of execution, current year funding may not be sufficient to accommodate new funding requirements, again creating potential delay and disruption to the program schedule.

In each of these cases, program schedules must be replanned to accommodate different funding realities. Reprogramming or repurposing current year funding is generally not simple or quick. Requests for more, or different, funding can take up to 2 years to realize through the Planning, Programming, Budgeting, and Execution system. Tasks must be trimmed in the current year and work adjusted so the financial impacts can be addressed over the longer term. The results may be that key events and milestones are missed, concurrency increases, and opportunities are lost.

Longer programs potentially suffer greater budgetary churn. Each new fiscal year presents an opportunity for decision makers outside the program to make funding "adjustments" that perturb the program's overall performance. Likewise, longer programs with large budgets can be tempting targets for comptrollers or Congress.

3

Developing Schedules

The Scheduling Process

The schedule development process itself may be a culprit in program cost overruns. Ideally, program schedules are developed in a rational and linear manner. Program requirements are analyzed and developed through the iterative systems engineering process, allocating required functions to be performed by the system's hardware, software, and operators. A work breakdown structure (WBS) is created, assigning those functions to subsystems and components. At the lowest level of the WBS, work packages are developed that allow accurate estimation of the resources—dollars, time, and manpower/expertise—required to build, test, and deliver the hardware or software widget. Rolling up these detailed resource requirements to higher levels of the WBS, then, allows the program management team to create an overall program budget estimate, resource-loaded schedule, and program manpower estimate. The resource-loaded schedule will show each task with its estimated duration and linkages to other tasks to show dependencies (e.g., Task B cannot start until Task A is complete), major milestones where tasks culminate in a defining program event, the calculated program end date, and associated critical path. If each task is then given the appropriate resources and completes within its estimated timeframe, then the program execution proceeds from start to finish with nary a problem.

Unfortunately, this is generally not how program schedules are constructed. Project end dates are more often arrived at from a capability "need date" established early in the program by the user or sponsor. In the survey of program management students at the Defense Acquisition University in 2011, only 18 percent reported that their program end date was determined through a roll-up of task level schedules, while 58 percent reported end dates determined by need.

Apparently, herein lies the source of some inherent program problems. In this method of program end date determination, the need date or end date is fixed and the program milestones are "backed out" from there. Other project tasks are fitted into the milestone scheme, along with whatever concurrency and optimism are needed to make the schedule "work." Fully 82 percent of the program management students participating in the DAU survey reported that their program schedules contained *some* to *significant* concurrency with *moderate* to *high* schedule risk.

In execution, to stay on schedule programs must accept risks, and, as the GAO has noted in its annual *Assessments of Selected Weapons Programs,* proceed through milestones before achieving requisite design and engineering maturity (GAO, 2009, 2010, 2011). This results in programs being, "at a higher risk for cost growth and schedule delays" (GAO, 2011).

Ninety-six percent of those polled reported that having an integrated and up-to-date schedule is critical to running their programs, and two-thirds express confidence in the accuracy of their master schedules.

Scheduling processes are not well understood or executed. The process of scheduling itself is difficult and may not always be as useful as it could be as a key project management tool. The National Defense Industrial Association (NDIA)'s Industrial Committee for Project Management recognized that the art of scheduling for complex projects was problematic for government programs and chartered the Program Planning and Scheduling Subcommittee to create the *Planning and Scheduling Excellence Guide* (NDIA, 2012). This guide was designed to assist government and industry in creating more useful, consistent, and standardized integrated master schedules (IMS) using the principles of the internationally recognized standard, *Generally Accepted Scheduling Practices*. The guide emphasizes practical skills and application of sound scheduling principles to create a schedule that models the acquisition plan, provides tips for schedule maintenance, and advice for project managers to use the IMS more appropriately to manage a complex government program.

The survey of PMs at the Defense Acquisition University revealed some insights into how schedules are viewed by current managers. Ninety-six percent of those polled reported that having an integrated and up-to-date schedule is critical to running their programs, and two-thirds

express confidence in the accuracy of their master schedules. However, less than half reported that their schedule is accurately resource-loaded, and only 51 percent are confident their schedule includes all the work required to be done by government and contractors. These results seem to be inconsistent and perhaps contradictory. Only half responded that their schedules are complete and accurate, yet most have confidence in the schedule and overwhelmingly affirm its importance to their program's success! The Table shown here summarizes these views.

3

TABLE. PROGRAM MANAGER VIEWS OF THEIR SCHEDULES

Statement	Agree or Strongly Agree	Neutral, Disagree, or Strongly Disagree
Having an integrated and up-to-date schedule is critical to running my program.	96%	4%
I have confidence in the accuracy of my master schedule.	65%	35%
My schedule is accurately resource-loaded.	45%	55%
My program schedule is realistic and achievable.	56%	44%
My schedule includes all required work, including that of government organizations, all contractors, and subcontractors.	51%	49%

Similarly, in execution, 56 percent responded that their schedule is realistic and achievable, while 40 percent report that their programs are behind schedule. When faced with hypothetical budget cuts, 48 percent indicated they would defer requirements or capabilities, while only 20 percent would slip schedule as a preferred method to manage overruns. However, the PMs assigned the highest priority for their programs as ensuring quality and performance of their products, and they ranked controlling program scope last in relative priority. Again, while their responses to questions of importance align closely with current policies of adjusting scope to budget, the practical priorities on performance and scope, as reported by the PMs, would seem contradictory.

Finally, when the statement is posed, "Maintaining an accurate detailed schedule is too labor-intensive and costly for the value," fewer than 10 percent agreed or strongly agreed. When asked about current program issues, respondents reported difficulty in synchronizing schedules among players second only to unstable funding. Again, this seems to indicate the importance PMs place on the theoretical value of their IMS, and a recognition that large program scheduling is, in practice, challenging.

Program problems can be created when program teams and stakeholders underestimate the challenges and overestimate their abilities to deliver on "success-oriented," aggressive schedules.

Overoptimism can lengthen program schedules and increase costs. Given that many program end dates are set well before any of the work begins, perceived necessity, concurrency, and optimism drive milestone schedules and tasks. Once the analysis of the work that must be accomplished is underway, tremendous pressure is pervasive in keeping to original agreements and promises to deliver, however unrealistic. In the "Conspiracy of Optimism" white paper, the International Centre for Complex Project Management (ICCPM, 2010) authors explain:

> Once initial project budgets and schedules are set, based on such estimates, they have immense staying power, driven by collective unrealistic expectations, even to the extent that over time, system functionality and project resources are sacrificed in order to achieve what was unobtainable in the first place.

Program problems can be created when program teams and stakeholders underestimate the challenges and overestimate their abilities to deliver on "success-oriented," aggressive schedules. This optimistic thinking necessarily flows down from the government to the system contractors. Once the government team has fallen into its own overly optimistic decision trap, contract requests for proposal are written based on the ill-conceived plan, and contractors then come to the table hoping to have the most attractive bid to meet the government's ill-conceived expectations. Unfortunately, this also often creates an environment

where realistic assessments of cost and schedule are undervalued, and contractors who refuse to join in on the conspiracy risk losing the job (Eden, Ackermann, & Williams, 2005):

> It is common for commercial considerations to lead to "doctoring" of the estimate in order to drive estimated costs down—particularly where there are strategic reasons for wanting to win that particular bid. Later, at the planning stage, this "doctoring" is forgotten and unrealistic plans are made. As the project unfolds, this lack of realism is very likely to play one of the most significant and unattributed roles in increased costs. Underestimating at the planning stage is one of the most common triggers for cost escalation . . . . (p. 19)

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Kahneman (2011) argues that the optimism bias is inherent and pervasive in individuals and teams taking risks under conditions of uncertainty or ambiguity. He offers that remedies to this bias are often gained through using a comparison of timelines for similar prior projects as a baseline for the current one, or getting an outside view from a third party who may be able to assess the reasonableness of project estimates. He also encourages the practice of "pre-mortems," where the project team envisions future project failure and offers all the things that might have caused it (p. 264). This exercise may empower the team to bring to light issues that have not been previously considered (or ignored), help break groupthink, and encourage the team to accept evidence of overoptimism in the project's planning.

Conclusions

While the quantitative evidence linking schedule to cost is murky, most of the literature agrees qualitatively that longer programs incur greater costs and cost overruns. Longer programs tend to be more complex and include significant technology development efforts. They are more susceptible to requirements changes and budget churn. Longer programs seem to have an affective component where time is undervalued and decisions can be deferred. Pushing work into the future can create a bow wave of work that must then be accomplished with more concurrency, thereby generating the need to apply additional resources in an attempt to meet the program delivery date. This limits the program's cost-schedule-performance trade-space and can lead to even greater churn.

Several potential remedies have been suggested by the literature. First, where possible, shorten program timelines from inception to delivery of a usable capability (a goal should be no longer than 6-½ years). This would expose higher risk requirements and technology development that could be done within a program and reduce the opportunities for requirements changes. Shortened programs would facilitate more accurate cost and schedule estimates, and fewer budget cycles would limit the opportunities for comptrollers and Congress to change program funding profiles.

Next, artificial program "need dates" should be compared with a rational bottom-up schedule derived from the WBS and systems engineering process. The bottom-up analysis should then inform a more reasonable program delivery date and moderate the amount of program concurrency. Similarly, overoptimism must also be tempered by objectively comparing current plans and schedules with similar past programs. Further, from the survey of senior defense PMs, it appears, at least in principle, that they value and appreciate the utility of good integrated schedules. However, it appears equally likely that inconsistencies and contradictions exist in how PMs use schedules in actual practice. These results imply that there may be a need for better training and a renewed focus on schedule development and management. Finally, PMs and acquisition leaders must understand and appreciate the linkage of cost and schedule, and the value of time to program success. Time, after all, is money.

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Keywords: *Performance Based Logistics (PBL), Governance Structure, Theory, Life Cycle, Make or Buy, Postproduction*

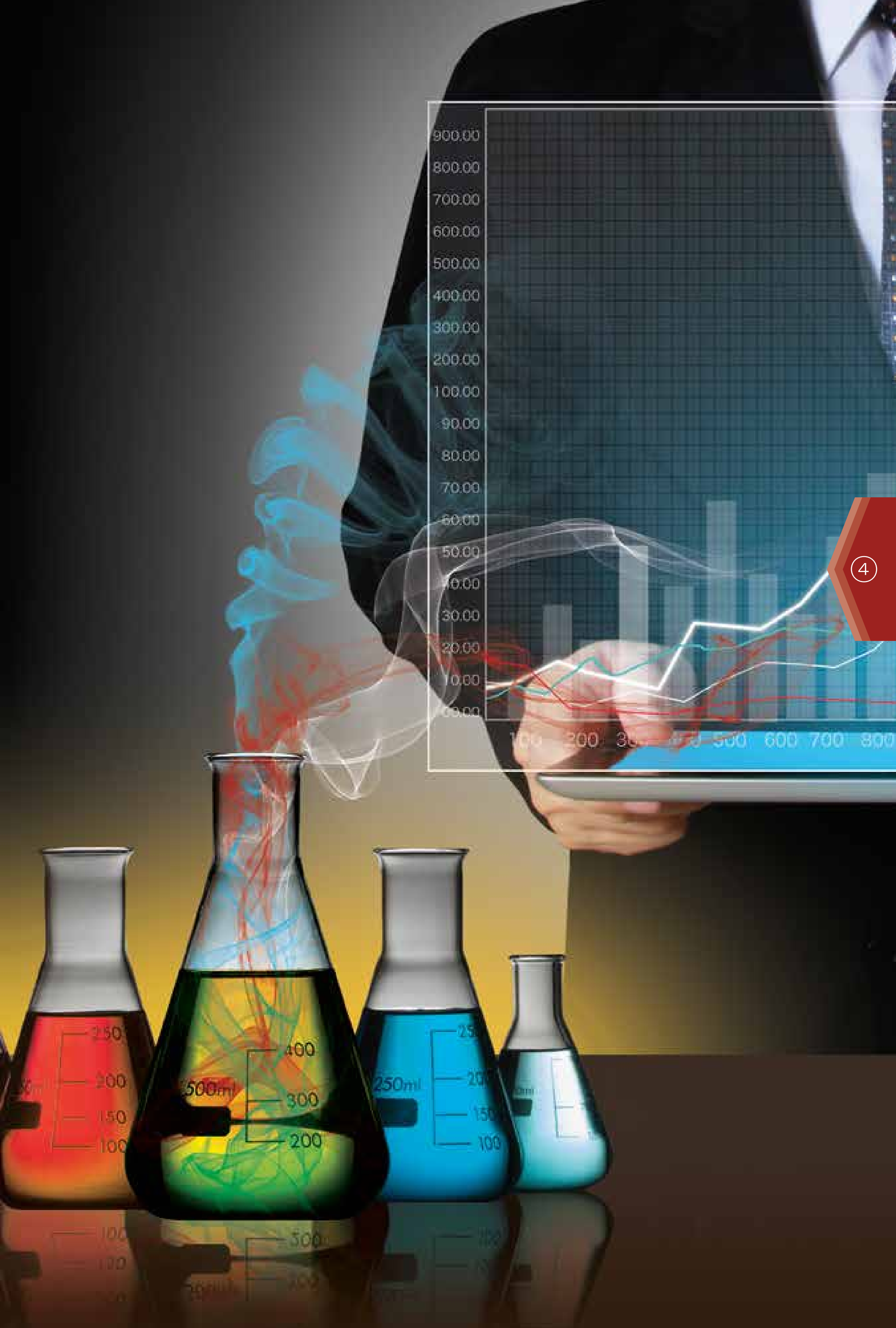
Are the Performance Based Logistics Prophets Using Science or Alchemy to Create Life-Cycle Affordability?

Using Theory to Predict the Efficacy of Performance Based Logistics

Wesley S. Randall

Numerous studies have provided evidence that performance based logistics (PBL) can control cost and improve performance. The success—and failure—of PBL strategies suggest the need to position the PBL research domain into a fabric of theory. Just as engineering theories predict the reliability of a new armored vehicle, economic and business theories provide a framework that explains the efficacy of PBL. This article describes the underlying theoretical fabric of PBL. Armed with a framework grounded in theory, senior leaders can make science-based decisions to explain, predict, refine, and advocate for affordability-enhancing, life-cycle governance structures by leveraging the critical success factors of PBL.

Image designed by Diane Fleischer »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In recent years, a great debate has surrounded the effectiveness of Performance Based Logistics (PBL). Articles have extolled the virtue and condemned the opportunism of PBL. In some quarters, consensus is growing that PBL works if you do it correctly (Boyce & Banghart, 2012). Initiatives like the DoD Weapon System Acquisition Reform Product Support Assessment (Department of Defense [DoD], 2009), Proof Point Project (DoD, 2011), and DoD guidance tell us the PBL debate is technically over. Yet, in other quarters there remains disagreement as to the efficacy of PBL.

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PBL is part of a family of strategies, such as performance based contracting and pay for performance, whose essence is a shift from purchasing discrete products and services to the purchase of performance (Kim, Cohen, & Netessine, 2007; Randall, Nowicki, & Hawkins, 2011). PBL success depends on interactions among numerous variables. For instance, short-term contracts generate quick wins in classic logistics (warehousing, transportation, and inventory), medium-length contracts improve purchasing and item management, but real reliability-driven affordability requires a longer term contract (Hypko, Tilebein, & Gleich, 2010; Randall, Pohlen, & Hanna, 2010). As is true of any science, PBL research has been a journey of discovery. Predicting PBL success can be summed up in words frequently echoed throughout the halls of the

Defense Acquisition University: "*It depends . . . .*" The logical next step in PBL, and the goal of this article, is to provide the business and economic science behind PBL success.

The most profound contribution of academic research is theory. Theory provides the power to explain, predict, and improve the future.

What is Science, Where Do We Use It?

The most profound contribution of academic research is theory. Theory provides the power to explain, predict, and improve the future. Imagine an engineer tasked to build a light armored vehicle capable of 10,000 miles without major overhaul. Without theory as a guide, how does that engineer complete the task? The engineer will likely look to what seemed to work in the past and often overbuild the vehicle. The engineer will range-test the vehicle, rework the design of what breaks, and keep going until the goal is met. Armed with engineering theory, our intrepid engineer is focused and efficient. Theory informs computer simulation, tests, refinement, production, and employment of a vehicle that works as predicted. To a degree, PBL today is that engineer relying on experience without theory. We have identified where PBL has worked—and hasn't worked—no small task. Now is the time to define a theory-based framework that guides PBL implementation and execution.

One of the first classes in a business PhD involves a philosophy of science. The goal of this seminar is to provide the aspiring academic a foundation to accept the idea of business theory. Typically, the class starts with theory from the hard sciences such as engineering and physics simply to lay out the idea of theory. The hard sciences are used because students generally have find it easier to accept the predictive validity of natural laws like gravity. There is little resistance to the idea that engineering theories will explain how a new material will impact system performance (e.g., reliability, maintainability, and supportability). In the hard sciences, the idea of innovation improving performance and reducing costs, even for fielded systems, is relatively concrete.

In the soft sciences, such as business and economics, the explanatory ability of theory is not so intuitively grasped. This is because business and economic theories are less precise in making point predictions, but fairly precise in making statistical predictions. While business theory will struggle to explain the success or failure of a particular firm, business theory is effective in making statistical projections about groups of firms. So it is not unreasonable for business theory to suggest that on average firms that increase their inventory turn rates will outperform those who do not (Arnold, 2002). The need to explain and predict general success in the marketplace and overall health of a national economy make business theory critical. Likewise, the hard science business theory takes some of the alchemy out of strategy. Without sound business theory, leaders may find themselves moving from one "fad strategy" to the next, not understanding why things work in one context and not the next.

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What Does This Mean for PBL?

The DoD budget realities highlight the need for strong, theoretically based, business acumen in weapon system sustainment. Such theory acumen is critical to the fiduciary responsibility of leaders charged with stewardship of defense budgets, warfighter effectiveness, and the success of the defense industrial base. The goal of this article is to lay a foundation for that acumen. Just as engineering theories explain the reliability of the new light armored vehicle, economic and business theories can be used to explain the efficacy of PBL and other postproduction support strategies.

Theory Foundation for Performance Based Logistics

In recent years, practical and academic PBL research in defense and beyond has experienced a veritable explosion (Boyce & Banghart, 2012; Guajardo, Cohen, Kim, & Netessine, 2012; Kim, Cohen, Netessine, & Veeraraghavan, 2010); Kratz & Diaz, 2012; Mirzahosseinian & Piplani, 2011; Randall, Pohlen, & Hanna, 2010; Sols, Nowicki, & Verma, 2007). Organizations looking to the World Bank for financial support to provide healthcare are expected to use a performance based toolkit (The World Bank, 2008). Siemens (2011) has an integrated performance based strategy for rail services. More than 35 countries are using performance based approaches for roads and highways (Transportation Research Board, 2009). The State of Illinois has been recognized for its performance based approach to child welfare services (Administration for Children &

Families, 2011). Nearly 70 percent of commercial maintenance, repair, and overhaul functions employ performance based strategies (Flint, 2007). Poignantly, our colleagues in the former Soviet Union provide concise insight into the essence of a performance based strategy (Organisation for Economic Co-Operation and Development, 2011):

> Ultimately, performance based contracts, if developed properly, can help to lay the basis for the long-term sustainability of water utilities, increasing their efficiency and creating conditions where investment capital can be attracted. (p. 3)

What does research say?

- PBL manufactures internal competition, eliminates waste, and improves quality (Boyce & Banghart, 2012).
- PBL aligns incentives to avoid suboptimization (Randall et al., 2010).
- PBL leverages long-term contracts to spur investment (Sols, Nowicki, & Verma, 2007).
- PBL optimizes management of assets that are difficult to predict statistically (Kim et al., 2010).
- PBL shifts from a return on sales to return on investment business model (Randall et al., 2011).
- PBL creates optimal outcomes while dealing with uncertainty and differing constraints (Kim et al., 2007).
- PBL creates a governance structure based upon long-term relationships, stable cash flow, clear scope, and intelligent metrics (Kratz & Diaz, 2012).

The net-net of this research activity is performance based strategies work.

Governance: So That's What PBL is Really All About

Research funded by the Naval Postgraduate School Acquisition Research Program and conducted by the University of North Texas Complex Logistics Systems Cluster (Randall et al., 2011) found:

> PBL establishes a metric-based governance structure where suppliers make more profit when they invest in logistics process improvements, or system redesign that reduces total cost of ownership. (p. 324)

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Governance is critical to business and economic theory. Oliver E. Williamson won a Nobel Prize describing firm governance. For Williamson and his colleague, William G. Ouchi (1981), governance is a way of organizing transactions. Governance is more than a contract; it is "a much broader concept than control. Essentially, governance includes elements of establishing and structuring exchange relationships as well as aspects of monitoring and enforcement" (Heide, 1994, p. 72). The essence of PBL is a governance mechanism that efficiently organizes complex supply chain transactions. Just as the efficiency of transaction "bundling" predicts the success of the firm (Coase, 1937), PBL provides a "consistent sustainment governance process institutionalizing a life-cycle perspective on affordable and effective product support from acquisition through operations and support" (Kratz & Diaz, 2012, p. 40).

Coase's Theory of the Firm: Rationale for a Product Support Integrator (PSI)

Ronald Coase, Williamson's mentor, won a Nobel Prize (The Ronald Coase Institute, n.d.), by asking a very elemental question: Why do firms exist? Using precise and brilliantly simple terms, Coase (1937) explained that firms provide a governance structure that, for some transactions, is more efficient than market transactions. The firm does this by avoiding the market costs associated with knowing true price, searching for products and information, and enforcing contracts. Value is created when, "within a firm, . . . market transactions are eliminated, and in place of the complicated market structure with exchange transactions is substituted the entrepreneur-coordinator, who directs production" (Coase, 1937, p. 388). For Coase, the firm is an entrepreneur efficiently bundling and integrating market transactions.

The ideas embedded in the Theory of the Firm provide a foundation to explore the contention that multiyear PBL contracts are monopolies. Long-term firm existence demonstrates that nonpure competition governance structures can provide value superior to frequent market competition. More specifically, competitive position is then based upon the firm's ability to integrate complex transactions more efficiently than what a customer could achieve in the market alone. The firm governance is a form of "internal competition," which uses profit as a source of learning (Hunt, 2000). When the PBL governance results in portions of profit being reinvested into innovation that drives future profit, the multiyear PBL creates internal competition where profit leads to learning that increases affordability (Randall et al., 2010; Randall et al., 2011).

The critical nuance that is often misunderstood by competition advocates is that profit, not competition, provides the signal that allows firms to learn.

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The critical nuance that is often misunderstood by competition advocates is that profit, not competition, provides the signal that allows firms to learn. Integrating complex transactions then is the key to the efficacy of the PLB strategy profit—learning cycle. Randall and his colleagues (2010) found:

> [that the] integrator acts as the network entrepreneur, bundling knowledge and capital resources to achieve the end user's requirements . . . integration links achievement of an outcome with network members' actions. (p. 43)

Effective PBL strategies demonstrate that monopoly is not synonymous with opportunism. Good PBL governance structure can mitigate potential opportunism by aligning profit-based incentives (Guajardo et al., 2012).

Transaction Cost Economics: Explaining Integrated Supply Chain Management and Long-Term Contracts

Coase's student, Oliver Williamson, was also a Nobel Laureate. Williamson (1971, 1975) wondered why megafirms did not vertically integrate complete markets. In his research, Williamson identified behavioral dimensions, which he labeled as bounded rationality, that limit the quantity of transactions a firm could effectively bundle. At a certain point, the coordination of transactions inside the firm becomes so complex, decision-maker capacity is limited by bounded rationality, and additional transactions result in disproportionate cost (Rindfleisch & Heide, 1997; Williamson, 1975). Further, this bounded rationality was proportional to the uncertainties and complexity associated with transactions (Rindfleisch & Heide, 1997).

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Bounded rationality explains the success of an integrated supply chain network when the transactions are complex. Weapon systems sustainment strategies are tremendously complex. Transaction Cost Economics (TCE) suggests that complicated tasks require an expert integrator and a diverse network of supply chain partners who have the decision-making capacity to avoid bounded rationality for their subsystem (Kim et al., 2010; Randall et al., 2011; Williamson, 2008). At the same time, bounded rationality explains how some more easily bundled transaction sets, such as an organic depot returning a part to specification, can be more cost-effective.

A second element of TCE relevant to PBL is opportunism. Williamson (1985, p. 47) defined opportunism as "self-interest seeking with guile." Transactional relationships have little safeguard against opportunistic behavior. The governance structure of the firm avoids opportunism associated with internal transactions by creating convergent goals, controlling activities, and rewarding success (Rindfleisch & Heide, 1997). If the PBL strategy is considered a "firm-like unit" for the purpose of governance, then TCE can be used to explain how metrics and long-term contracts create convergent goals, control activities, and reward goal achievement through profit. For complex transactions, the PBL supplier network, working under sound governance, aligns metrics and profit to provide a learning process superior to frequent competition and minimizes the effects of bounded rationality.

In transactional sustainment, little incentive exists, and even less capital is available, to make life-cycle affordability investments. PBL reverses that trend by treating repair and redesign similar to make or buy.

Make or Buy Decisions: Know When to Hold 'em (Repair) and Know When to Fold 'em (Redesign)

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A defining element of a complex system is one where the postproduction spend significantly exceeds the production spend. Unfortunately, that postproduction spending at best simply maintains the status quo. In transactional sustainment, little incentive exists, and even less capital is available, to make life-cycle affordability investments. PBL reverses that trend by treating repair and redesign similar to make or buy.

Simply put, make or buy predicts, when all transactions costs are considered, if firms should make or buy an item (Coase, 1937; Walker & Weber, 1984; Williamson, 1985, 2008). The make-or-buy decision seeks "the most efficient mode of governing the transaction" (Walker & Weber, 1984, p. 373). The idea underlying the choice of make or buy is similar to the spare-or-repair decisions predicted by the PBL governance structure. The goal in make (repair) or buy (redesign) is to seek the most cost-efficient approach to satisfy demand for some item.

PBL and non-PBL managers focus on gaining efficiency and effectiveness regarding inventory management, repair, and overhaul. Yet, for the PBL manager the money spent purchasing spares, repairs, and overhaul is continuously calculated against an investment in new materials, processes, and technologies that will improve reliability and correspondingly drive out demand for that particular spare part (and its warehouse, inventory, and transportation cost), along with repair or overhaul tasks (Randall et al., 2011).

When a supplier has a new process that reduces the cost to redesign (buy) a part, then the PBL strategy dictates a shift from repair to redesign. Figure 1 graphically depicts using the idea of make or buy for repair

or redesign. The vertical axis denotes the financial case for repair or redesign. The horizontal axis represents different parts. The parts that appear on the left and right side have a clear financial case. The ability of the PBL governance to use innovation and investment to move the parts near the middle from repair to redesign is the essence of life-cycle affordability. In transactional postproduction support, there is no governance mechanism to shift the repair-redesign frontier.

The long-term contracts create pools of monetized cost avoidance that represent potential profit when the repair-redesign frontier is moved to the right. The profit pools provide the suppliers an incentive to invest in new material, process, and capabilities that will push items across the repair-redesign efficient frontier. Thus the learning—investment—profit cycle of PBL overcomes the potential opportunism of limited external competition.

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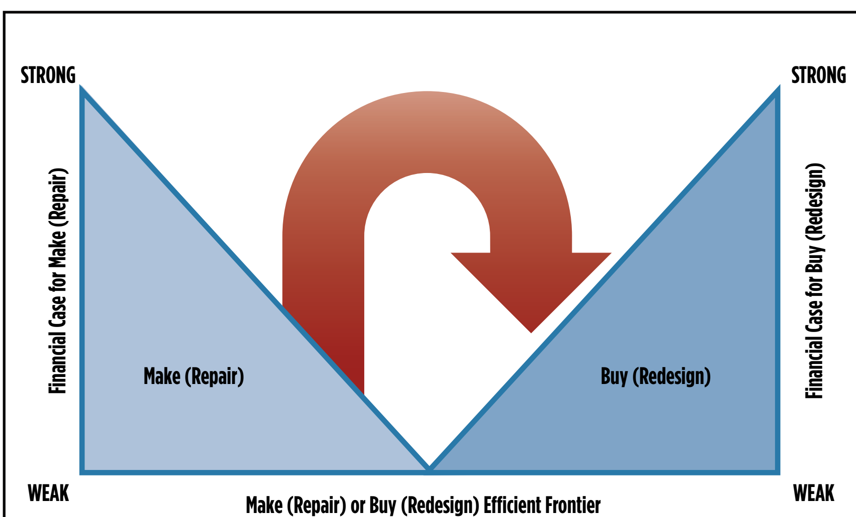
FIGURE. GRAPHIC DEPICTION OF THE IDEA OF MAKE OR BUY FOR REPAIR OR REDESIGN



The idea that new materials, processes, and technologies will move parts across the redesign frontier is fairly intuitive. The economic case for shifting from repair to redesign is less intuitive. The costs associated with redesign can be daunting; they include the engineering hours of the design itself, production of parts, changes to the configuration baseline and technical orders, new test equipment, and new spares. However, the cost associated with continuous repair is very real. Ultimately, life-cycle

cost reduction requires managers to recognize a compelling case for the recovery of nonrecurring costs linked to redesign. The math associated with redesign is fairly surprising.

Table 1 provides a redesign economic model. This example illuminates the impact that contract length has on the repair-redesign decision. Targeting demand reduction on a few key parts can have significant impact on affordability. This example assumes constant year dollars, and no weighted average cost of capital discount. Given that a $7 million component redesign doubles the mean time between failure, and that doubling reduces demand for that component by 50 percent (200 to 100 demands per year), a rational actor, given a 3-year contract, will not invest the $7 million in nonrecurring redesign costs. However, extending the contract by 1 year, we find that a rational actor will make the redesign investment. Universally, when a component switches from repair to redesign, both the near-term (on-equipment maintenance) costs and long-term (total life-cycle) costs go down for the customer. Once the nonrecurring costs are recouped, the cost avoidance piles up for the remaining life of the system—increasing affordability.

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TABLE 1. IMPLICATION OF CONTRACT LENGTH ON REPAIR VERSUS REDESIGN EFFICIENT FRONTIER

	Repair	Redesign
Demand	200	100
Cost per repair	$20,000	$20,000
Nonrecurring	$0	$7,000,000
Total cost year 1	$4,000,000	$2,000,000
Cumulative cost	$4,000,000	$9,000,000
Total cost year 2	$4,000,000	$2,000,000
Cumulative cost	$8,000,000	$11,000,000
Total cost year 3	$4,000,000	$2,000,000
Cumulative cost	$12,000,000	$13,000,000
Total cost year 4	$4,000,000	$2,000,000
Cumulative cost	$16,000,000	$15,000,000
Total cost year 5	$4,000,000	$2,000,000
Cumulative cost	$20,000,000	$17,000,000
Cost Savings Redesign		$3,000,000

Note. For simplicity, analysis does not consider discounted net present value.

In PBL, contract length directly impacts the repair-redesign efficient frontier and has tremendous implications for life-cycle affordability.

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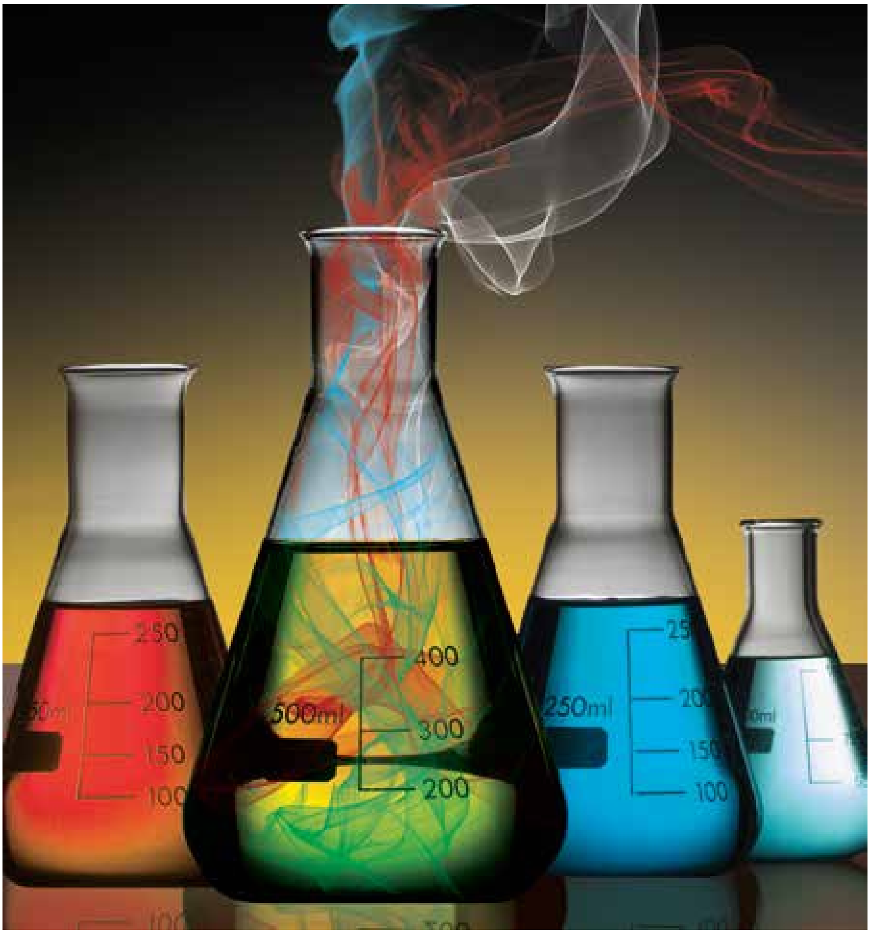
In PBL, contract length directly impacts the repair-redesign efficient frontier and has tremendous implications for life-cycle affordability. The length of a specific PBL contract depends on the potential to drive out cost by redesign, recovering nonrecurring costs, and the costs associated with repair. This raises the question, is there an end point where no more cost can be avoided? In theory, yes; in practice, no. The key determinants for success will be the availability of new processes, materials, and technologies, and the ability to monetize out-year spending. As long as innovation and supply chain collaboration results in a shift from repair to redesign, and as long as defense postproduction spending accounts for billions of dollars, PBL-type strategies will continue to produce efficiency and effectiveness improvements.

Core Competency: Exactly Who Should Do What and Why?

Significant PBL discussion is still ongoing about who should do what and why. A 1990 *Harvard Business Review* article by Prahalad and Hamel (1990) provides a theory-based way to answer that question. They discuss the idea of core competency as a framework to integrate organizations that have the complementary "core competencies" needed to achieve success. Core competencies are "the most powerful way to prevail in global competition" (Prahalad & Hamel, p. 79). Core competencies are central to business success. By definition, the core competencies of a firm are difficult to imitate, versatile in the marketplace(s), and protect against commoditization by being recognizable as significant value to the end customer (Prahalad & Hamel, 1990). Recognizing what core competencies are and are not allows business strategists to figure out when to partner, and who should do what.

The idea of core competency should drive the teaming strategy of the PBL governance structure. For example, generally, the entity that designed and produced the part will have the highest redesign core competency. When a third party offers a lower cost solution, this is likely to

be the result of some externality (e.g., the third party wanting into the market, the third party developing some type of Schumpeterian innovation, the original equipment manufacturer [OEM] losing competency, or an inefficient OEM cost structure). The competency logic also applies to purchasing, inventory management, warehousing, and transportation. Core competency explains why highly successful third-party logistics providers, like Menlo Logistics, are valued DoD partners. When it comes to repair and overhaul, the DoD depots have established core competencies that often make them the smart partner of choice. Few would argue the ability of Tinker and Jacksonville to overhaul engines, or Ogden to rebuild landing gear. Core competency provides a theory-based framework for decision makers to predict who should be doing what and why.



It makes sense that suppliers would bear the risk for performing typical logistics functions, while also making the repair-redesign decision. Yet, risk management is about balancing risk and reward.

It's About Risk

Risk allocation and, more specifically, placing risk where it is handled most cost-effectively is elemental to PBL (Randall et al., 2011):

> PBL represents a governance structure that drives responsibility for supply chain transactions to those entities most capable of completing those transactions at the least cost and lowest risk. (p. 343)

It makes sense that suppliers would bear the risk for performing typical logistics functions, while also making the repair-redesign decision. Yet, risk management is about balancing risk and reward. Not uncommonly, PBL contracts may specify some type of gain sharing when profits exceed a certain level, subject to investments having been recovered. At the same time, it may be appropriate that customers share in costs associated with unforeseeable circumstances. Both ends of the risk-reward spectrum can be addressed by the governance structure.

Supply Chain Management: On the Rise

In a landmark 2001 *Supply Chain Management Review* article, Rice and Hoppe (2001) argued that competition is no longer firm against firm, but supply chain versus supply chain. Improved connectivity, increased efficiency, higher quality, and standardized processes have reduced supply chain transaction costs (Kaipia, 2009). Supply chain management efficiently brings together firms with complementary core competencies.

How significant is the rise in supply chain management? Manufacturers spend 40 to 70 percent of the cost of goods on purchased goods and services (Trent, 2007). The efficiency of supply chain governance structures and the ability to integrate complementary core

competency have resulted in transactions moving from the firm to the supply chain. Even Walmart goes to the supply chain for logistics support—Exel Logistics manages Walmart's Canadian logistics operations. Bose has heavily integrated suppliers into its research, design, and manufacturing.

Effective supply chain management can deliver products and services that create customer value at the least total cost. Supply chain management *value* (outcome divided by cost) is based upon the ability of the integrated supply chain to exceed the value of internally managed transactions (Lambert & Garcia-Dastugue, 2006; Walker & Weber, 1984, 1987). The rise of efficient supply chain governance structures is not coincidental to the rise of PBL success.

Providing value is inherently a return on investment strategy and requires a long-term relationship between customers and suppliers.

Service-Dominant Logic: A New Exchange Framework—And It Looks a Lot Like PBL

Scholars Stephen Vargo and Bob Lusch (2004) recently developed a new framework for market exchange called Service-Dominant Logic (SDL). SDL suggests that economic expansion and competitive position can be predicted based upon the supplier networks' ability to leverage knowledge to create evolving customer value. Similar to PBL, SDL creates value not by delivering products, but by using knowledge to create performance.

In SDL, the product is not in and of itself valuable—the product is a distribution mechanism for value (Lusch, 2011). This value focus is similar to PBL. In PBL, the metric provides a value-based feedback mechanism. Specifying delivery of performance, not products, leaves the suppliers free to invest in innovation, create cost avoidance, and harvest profits. This dynamic creates learning, rewards investment, and spurs new investment. Similarly, in SDL the primary flow is knowledge, and integration is the highest core competency.

The idea of PBL as an application of SDL has received considerable attention in academic circles. A 2011 PBL-focused article in the *International Journal of Logistics Management* won the emerald literati commendable paper award (Randall et al., 2011). That article states that SDL:

> . . . provides an effective mechanism to show how certain PBL ecosystems, their suppliers, customers, and integrator, can efficiently adapt to environmental changes, and thus predict competitive advantage of that network. The key to that competitive advantage is the flow of knowledge-based resources between the supplier network partners as focused on satisfying a customer service requirement. (p. 332)

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Providing value is inherently a return on investment strategy and requires a long-term relationship between customers and suppliers. The knowledge orientation of SDL and its focus on creation of value, not simply supplying product, provides an economic foundation to predict the success of a PBL governance structure that aligns metrics, incentive, knowledge management, integration, capital, supply chain relationships, and learning to create affordability.

Research should seek to develop design solutions, coupled with efficacious PBL governance structure, thereby enabling cost-effective innovation across a program's life.

A Framework for PBL Governance Decisions

PBL rests on a fabric of sound business and economic theory. PBL governance structures minimize the costs associated with filling demand for parts, while continuously reevaluating how new material, processes, and technologies can improve reliability and repair efficiency, reduce demand for parts, and decrease life-cycle cost.

This implies a powerful, yet fairly simple PBL-based Life Cycle Affordability framework (Table 2). Given a proper PBL governance structure, affordability can be achieved by reducing the supply chain cost associated with meeting demand for parts (X-axis) or reducing the demand for parts and cost of repair (Y-axis). Program characteristics (e.g., parts demand) can be used to determine differing potential, contract structure, and partnerships—governance.

TABLE 2. LIFE-CYCLE AFFORDABILITY FRAMEWORK

Reliability and repair potential	LOW Supply chain integration potential	HIGH Supply chain integration potential
HIGH	**Cost avoidance potential — Medium** • Demand for parts is low • Demand for repairs is low • Redesign potential is high **Potential opportunities:** • Reliability, repair, and diagnostic	**Cost avoidance potential — High** • Demand for parts is high • Demand for repairs is high • Redesign potential is high **Potential opportunities:** • Supply Chain, reliability, repair, and diagnostic
LOW	**Cost avoidance potential — Low** • Demand for parts is low • Demand for repairs is low • Low, or risky redesign potential **Potential opportunities:** • Limited	**Cost avoidance potential — Medium** • Demand for parts is high • Demand for repairs is high • Low, or risky redesign potential **Potential opportunities:** • Supply chain

Quite simply, how quickly and cost-effectively new materials, processes, and technologies are infused into a PBL program is the essence of affordability. Research should seek to develop design solutions, coupled with efficacious PBL governance structure, thereby enabling cost-effective innovation across a program's life.

Summary

This article uses business and economic theory to weave a theoretical framework that gives leaders the ability to explain, predict, refine, and advocate for effective PBL strategy. The theory of the firm provides a mechanism to the role of an integrator to act as the network entrepreneur who reduces transaction cost and efficiently links actions with outcomes. TCE affirms the role of integration, while describing in theoretical terms how PBL governance addresses bounded rationality and opportunism. Bounded rationality and the idea of core competency explain why PBL strategies benefit from the network of firms collaborating to increase affordability. Understanding opportunism gives insight into how monetizing cost avoidance ameliorates the negative aspects of a monopoly partnership. Ultimately, profit leads to learning, and learning leads to smart investment—thus profit, learning, and investment cannot be. DoD can continue to spend on spares, repairs, and overhaul, or it can create partnerships that leverage new materials, processes, and technologies and *supplier* investment to improve affordability. TCE shows how the PBL governance structure manufactures internal competition that is more efficient than frequent market competition for complex transactions. Make or buy explains how shifting from repair to redesign is the essence of affordability, and the role of contract length in that decision process.

Supply chain management is shown to provide the complementary core competencies needed to create affordable complex systems. PBL also uses the idea of competency to drive risk to the point where it is managed most cost-effectively. PBL is shown to be a practical implementation of the SDL exchange paradigm. This means the massive expansion of high-quality, peer-reviewed research into SDL research provides a readymade foundation to further the efficacy of PBL. In PBL and SDL, what matters most to customers is performance (service), not parts (products).

Conclusions

The Proof Point Project (Boyce & Banghart, 2012) provided empirical evidence of PBL success. This article augments that effort by providing the business and economic theory at the core of that success. The criticality of reducing a weapon system's life cycle demands that senior leaders

inculcate into the acquisition corps a respect for business theory—similar to the strong respect that the corps has for engineering theory. It is critical that decision makers continue the intellectual engagement aimed at understanding the theoretical and practical foundation for successful PBL governance structures.

Can we do better? Certainly. But let's not forget what we have done. DoD has provided the most capable and reliable warfighting systems ever known. I have personal experience with a number of these systems, and I am awestruck by their capabilities and the competencies of the men and women who created them. At the essence of PBL, we encounter familiar concepts. We know how to team. We know how to invest. We know how to blend core competencies—sea, land, air, and space. We know how to innovate. PBL simply provides a rational governance structure that blends new ideas with old ideas to create more affordable systems. The Life Cycle Affordability Framework for PBL is encapsulated in Table 2. What is left is a few guiding thoughts on how managers might implement these insights via the framework. Table 2 provides those thoughts.

In capitalism, the metric for success is *profit = revenue – expense*. In DoD, the metric for success will be quantified as capability (*assets x readiness*) where *capability = budget – cost*. An effective entrepreneurial program leader will increase capability (i.e., lethality, maintainability, and/or reliability) by leveraging innovation and governance to lower cost. To that end, grooming leaders and program integrators who function as business-savvy entrepreneurs is essential to the success of the nation's warfighters.

Business theory allows one last prediction. Leaders have a choice. Those leaders who choose not to develop a theoretical understanding of life-cycle affordability may unwittingly begin to resemble mercurial alchemists, with a frustratingly inconsistent ability to reduce weapon system life-cycle cost or explain the efficacy of affordability-oriented strategies like PBL. Leaders who do not understand theory will be forced to watch as their peers explain, predict, refine, and advocate for PBL success after success. Leaders armed with theory will understand how to employ PBL strategy to build collaborative supply chain governance structures that increase the affordability of national security.

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Author Biography

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Keywords: *Contingency, Expeditionary Contracting, Planning, Integrated Planner and Executor (IPE) Model, Adaptive Planning and Execution System (APEX)*

Phase Zero Contracting Operations—Strategic and Integrative Planning for Contingency and Expeditionary Operations

E. Cory Yoder, USN (Ret.), William E. Long, Jr., and Dayne E. Nix

Contracting in expeditionary operations is not new. What is new is the scope and magnitude of the roles that contracting and contractors play in today's military operations. Lack of planning and sound contract integration at the strategic level leads to inefficiencies, ineffectiveness, and, in many cases, outright fraud. Annex W, *Operational Contract Support Plan*, is the overall operations plan for Geographic Combatant Commands and the Services within the Adaptive Planning and Execution System framework. The authors propose an Integrated Planner and Executor (IPE) model for *operational contract support* and its integration into Annex W and existing war planning systems by congressionally mandating, authorizing, and funding IPE positions within Service structures. The IPE would be vested with the authority to establish, monitor, and manage Annex W.

Image designed by Diane Fleischer »

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Military organizations throughout the world are increasingly called to perform missions and create outcomes that are reliant on contractor support. In fact, contractors perform myriad functions in modern, often complex, military operations. Additionally, the military services are subject to ever increasing scrutiny and accountability to become better stewards of scarce resources, to eliminate potential waste, and to reduce abuse of taxpayer money due to poor management, operational redundancy and duplication of effort, and outright corruption.

Military Stands to Gain from Newest Initiatives in Doctrine

Because of an increased reliance on contractors and recent demands for improved accountability and performance, the authors contend that international military organizations will benefit by incorporating Phase Zero Contracting Operations (PZCO), and strategic and integrative planning for contingency and expeditionary operations. The PZCO concept has gained high-level attention as it is now embedded in Joint Publication (JP) 5-0, *Joint Operation Planning* (Chairman of the Joint Chiefs of Staff [CJCS], 2011), and in JP 4-10, *Operational Contract Support* (OCS) (CJCS, 2008), and currently under revision. Additionally, PZCO protocols were proposed and published in 2010, and the concept has gained popularity among military leaders seeking to improve military capability while following sound business practices (Yoder, 2010). PZCO, in essence and conceptually, is somewhat already embedded in recent doctrine, specifically within JP 5-0 and JP 4-10. However, it is not being fully implemented. This article addresses shortfalls in implementation, conceptually and pragmatically. Additionally, the authors utilize two analytical frameworks—the Three-Tier Model (TTM) and three pillars for integrative success—to identify shortfalls and recommendations for improvements.

The PZCO concept for strategic leaders and planners is presented, including the scope and magnitude of current and future contractor support, the need for integration and coordination amongst stakeholders, key PZCO model constructs, and alignment with key aspects of the Adaptive Planning and Execution System (APEX), which must include contracting. Finally, conclusions and recommendations are provided for forward-thinking leaders and planners.

The Scope and Magnitude of Contractor Support in Expeditionary Operations

Contracting in expeditionary operations is not a new phenomenon. What is new is the scope and magnitude that contracting and contractors play in today's military operations. For example, in March 2011 the Congressional Research Service reported that in the Central Command Area of Responsibility, the ratio of contractors to uniformed personnel supporting operations was .81:1 (Schwartz & Swain, 2011). Even if global operating tempos decline, many experts believe that reliance on contractor personnel will remain at current levels, or even grow, in relation to the number of uniformed personnel. *The New York Times* reported in February 2012 that 113,491 contractor personnel were in Afghanistan compared to 90,000 U.S. soldiers (Nordland, 2012). It should be noted that not all contractors in theater were directly supporting Department of Defense (DoD) operations in that, for example, the United States Agency for International Development and many private volunteer organizations and nongovernmental organizations utilize contractors and may be included in *The New York Times*-reported tally.

Particularly noteworthy is the scope and variety of contracted functions. These functions include base operations support, weapon systems support, security services, and a host of others.

Based on continued public and political pressure to keep organic uniform force structures low, the continued reliance on contract support for military operations is not likely to wane.

High Reliance on Contracted Support Has Created Challenges

Based on continued public and political pressure to keep organic uniform force structures low, the continued reliance on contract support for military operations is not likely to wane. Nevertheless, this high reliance on contractor support has also created challenges for military planners, operators, contracting units, and even for the contractors themselves. Challenges have manifested in command and control, in integration into Geographic Combatant Command (GCC) battle and

operational schema, and in the need for advanced planning, phasing, and timing of contracting events to synchronize with and complement operations plans (OPLAN). Additionally, planners must consider communications and movement plans, weapons control, compliance with Host Nation and Status of Forces Agreements (SOFA), contract management and oversight, indemnity and insurance of government-contracted personnel, prevention of human trafficking, third-country national labor protections, issuing and maintaining security clearances, and lawsuits under the Defense Base Act, to name only a few. Many of the challenges stem from a shift in organic uniformed-force capability to a contracted capability—from "doing" to "managing." So what can military leaders and planners do to effectively and efficiently manage all of these aspects of contracted support? The incorporation of PZCO into the design and construct of military planning will address many of the challenges identified previously.

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Credentialed Contract Planners Integrated with Operations Planners and Stakeholders

The TTM, a credential-based personnel hierarchy for contracting officers and planning staff, was published to address the challenges inherent in contracting in complex military operations (Yoder, 2004). It optimizes the integrative planning, coordination, and execution required for contingency and expeditionary operations at the tactical, operational, and strategic levels of the organization. The model is based on two primary premises. First, mission optimization occurs only with well-credentialed contracting planners and executors. Second, optimized stakeholder integration, including, for example, operational commanders, supporting units, nongovernmental organizations (NGO), and private voluntary organizations (PVO), can only be accomplished by utilizing well-credentialed participants in the planning and execution phases (Yoder, 2011).

Phase Zero Contracting Operations—The Three-Tier Model

The TTM has specific personnel credentials in three primary tiers: (a) Tier One—Training and education; (b) Tier Two—Certification (such as Defense Acquisition Workforce Improvement Act [DAWIA] contracting levels, security clearance requirements, etc.); and (c) Tier Three—Experience.

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The three tiers are described in the following paragraphs.

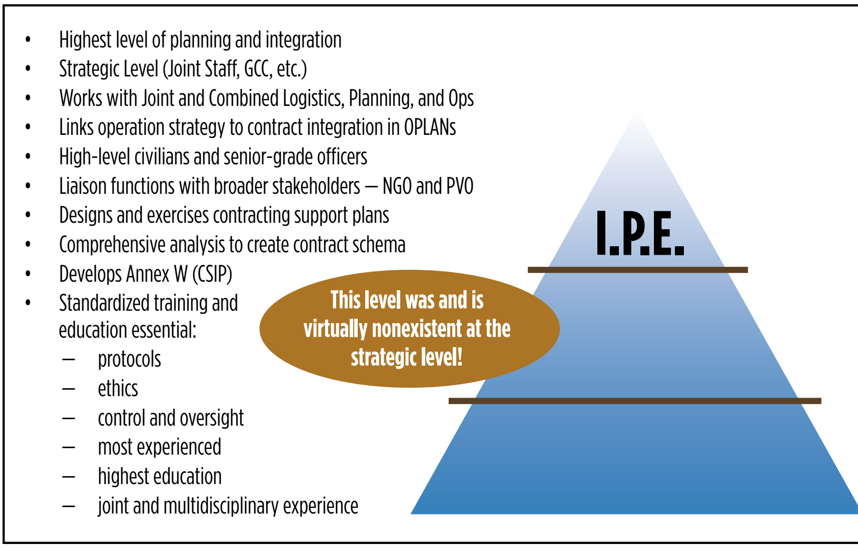
In Tier One, the ordering officer serves at the lowest level. This contracting level has several identifying attributes. Tier One personnel reside within the tactical level of the military hierarchy and are the most prevalent contracting personnel within most formal military and civilian organizations. The Tier One personnel are junior civilians and military staff. They operate at the tactical and unit levels, and perform no integrative planning at the operational and strategic levels. Tier One personnel place basic orders and conduct simple transactions. In the broadest terms, little stakeholder integration is being initiated or managed at this level. However, this lowest level is absolutely essential because it represents where a majority of "in-the-field" contracting actions are conducted. Tier One is the tactical level of the enterprise. Particular importance at Tier One is placed on standardized training—emphasizing protocols, ethical conduct, management, control, and oversight.

In the middle of the hierarchy is Tier Two, which leverages the capabilities of contracting officers who serve at the operational level. The Tier Two personnel require enhanced credentials. These personnel conduct complex contracting transactions and leverage local economy assets. They may perform all functions associated with Tier One personnel, but with increased credentials, scope, and responsibilities. The TTM calls for Tier Two personnel to be mid-level civilians, mid-grade officers, or credentialed senior enlisted. They can be integrated into planning and local operations, performing some integrative planning at the tactical and operational levels; and they can perform some liaison functions with broader stakeholders. Their main mission is to optimize local operations in harmony with strategic guidance. They will also prepare Annex W, *Operational Contract Support Plan*, when serving on a Joint Task Force staff during crisis action planning. Since Tier Two personnel serve at the operational level of the organization, expertise in the protocols, ethical conduct, management, control and oversight, conduct of complex negotiations, broad business acumen in complex military contracting, and phase I Joint Professional Military Education (JPME I) is required. Currently, the Naval Postgraduate School and the Defense Acquisition University offer CON 234–Contingency Contracting and CON 334–Advanced Contingency Contracting courses to standardize education in the contingency contracting business field.

An IPE must be strategically positioned within the organization to achieve the highest levels of integrative planning.

The highest and most crucial tier in the TTM is Tier Three, the flag officer or senior civilian position designated as the integrated planner and executor (IPE). The Tier Three personnel are at the strategic level of military and civilian organizations. Tier Three calls for the highest credentials including, but not be limited to, JPME I & II, DAWIA Contracting Level III certification and warrant (or international equivalent), a graduate degree or higher, a Top Secret security clearance, and experience in operations and contracting gained through experiential tours or assignments (Yoder, 2010). Figure 1 highlights the key aspects of the IPE position (Yoder, 2011).

FIGURE 1. THREE-TIER MODEL: TIER THREE, INTEGRATED PLANNER AND EXECUTOR



Source. (Yoder, 2010)
Note. CSIP = Contract Support Integration Plan

An IPE must be strategically positioned within the organization to achieve the highest levels of integrative planning. The IPE's primary mission is creating and validating a comprehensive Annex W to complement all elements of the OPLAN. Ideally, the IPE position should be placed within the Joint Staff, at GCC, and at the highest operational and planning staffs within each Service branch.

The IPE will create and validate Annex W in all key GCC OPLAN and concept plan (CONPLAN) elements. (Specific content elements of Annex W are presented later in this article.) Because of the complexity and magnitude of the tasks involved in creating and validating comprehensive plans, the IPE requires a supporting staff and subordinate expertise in key strategic and analytical areas, such as OPLAN analysis, logistics assessments, contracting, and similar professional disciplines.

Of note, most organizations do not have a dedicated contracting IPE (by any moniker) within their organizational structure. Traditionally, the joint logistics (J-4) organizations have embedded contracting officers. However, the contracting positions within J-4, or within traditional logistics organizations, have been utilized as adjunct positions to the

broader logistics functional planning. Additionally, because of the relatively low military rank and lack of seniority, contracting personnel on J-4 staffs often lack both the credentials and the clout to effectively execute the requirements proposed for the IPE.

Despite the DoD Components and military services lacking an IPE at the strategic level, the National Defense Authorization Act of 2008 (NDAA, 2008) made significant impact at addressing credentialed personnel shortfalls at the strategic level. The NDAA 2008 authorized and established the Joint Contingency Acquisition Support Office (JCASO), directed by a military one-star flag officer, positioned within the Defense Logistics Agency. JCASO has a staff of 49 personnel expressly to provide IPE strategic-level assistance and contract support to GCCs. These JCASO specialists work with GCC planning staffs to incorporate essential contracting plans at the GCC. According to Navy Rear Admiral Ron J. MacLaren, director of JCASO, each GCC is allocated two specialists from JCASO to assist in the development and exercise of each key OPLAN's Annex W (MacLaren, 2012).

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Will the DoD Components and the military services embrace the TTM, particularly the IPE function established by NDAA 2008 as the JCASO? Currently, JCASO has not been empowered with authority to compel GCC or the DoD Components and military services to utilize their OCS development functions. Rather, it represents an advisory group

that must "sell" its capabilities to improve mission support through integrative planning (MacLaren, 2012). Only time and sound metric analysis will prove whether or not the JCASO is effective at creating the needed Annex W OCS plans mandated and needed for key GCC OPLANs.

What specifically will the IPE position accomplish, and what will it achieve? If the warfighters are to embrace OCS, they must understand what essential functions the IPE achieves, and how those functions will yield benefits.

Phase Zero—Planning, Exercising, and Rehearsal

Phase Zero, generally known in GCC planning arenas as the shaping phase, is adopted by the OCS contracting community as the planning and exercising phase. Traditional military jargon defines Phase Zero as "shaping." Phase Zero contracting in the integrative strategic planning arena is the advance planning, exercising, and rehearsal of robust contracting support plans designed to complement the GCC's deliberate and contingency planning process. Realistically, the contracting community and the warfighter have the same vision for Phase Zero—get the plans in place, then rehearse, validate, and update them to reflect current realities. In essence, Phase Zero contract planning and the creation of OPLAN Annex W became *mandatory* under NDAA 2008 (Government Accountability Office [GAO], 2011). The authorization and supporting guidance under JP 4-10 (CJCS, 2008), requires all GCCs to create Annex W for OPLANs, representing the embodiment of Phase Zero integrative planning. However, despite the mandate, what is particularly disconcerting is that the GAO recently determined that only four out of 39 OPLANs requiring comprehensive Annex W integration plans actually had them (GAO, 2011). The low rate of Annex W integration may be a result of the challenges in assimilation and normalization of new doctrine and processes that DoD initially approved in 2008. MacLaren indicates that significant work is ahead to get all the GCC OPLAN Annex W support plans in place and exercised (MacLaren, 2012). The authors contend that current operational tempos, along with constrained budgets, may preclude achieving fully integrated exercises and rehearsals for all OPLANs, as these rehearsals can carry a huge price tag. However, failure to exercise and rehearse, based on recent and well-documented problems in Iraq and Afghanistan, results in costs that far outweigh the up-front costs to fully vet Annex W plans. Deliberate planning and contingency planning are different—the first is not necessarily time-sensitive, but the second may be very time-sensitive and is often constrained. While

JCASO has assigned two specialists at each GCC to assist in creating and exercising each Annex W, ultimately, the DoD Component and military services' contract warrant holders will be responsible for providing actual contract support, and must be included in the planning, exercise, rehearsal, and execution of the OPLAN. For the most critical OPLANs, sound strategy requires the exercise and rehearsal of each Annex W with the personnel that will ultimately be called into action.

Ideally, each OPLAN and CONPLAN will have an Annex W, fully drafted, exercised, rehearsed, analyzed, and revised. The doctrinal framework published in JP 5-0, along with JP 4-10, is key for the design and integration of contracting into OPLANs. The authors note that JP 5-0 does not currently require an Annex W—only JP 4-10 requires it. The objective is to embed and synchronize the OCS plan with all elements of the OPLAN to meet the commander's intent. Properly constructed Annex W plans must include elements such as, but not limited to, personnel/organizational structures and authorities; business protocols, including special statutory and regulatory provisions under declared contingencies; scheme of operations; synchronization with the battle plan; oversight; management and auditing; personnel regulations and provisions; spend analysis integration; synchronization with broader strategic objectives; and metrics for assessment of the efficiencies and effectiveness of embedded plans and actions (Yoder, 2011).

To ensure the efficacy of the integrated Annex W plan, the IPE must act as a strategic liaison with key stakeholders. Analytical assessments of the Annex W plan may utilize strength, weakness, opportunity, threat (SWOT) and capability gap analysis techniques. The SWOT method allows the IPE to evaluate the strengths, weaknesses/limitations, opportunities, and threats; and, ultimately, the potential efficacy of the OPLAN's integrated contracting plan. The capability gap analysis determines the support and provisioning gaps in the OPLAN that may be addressed through contracted support.

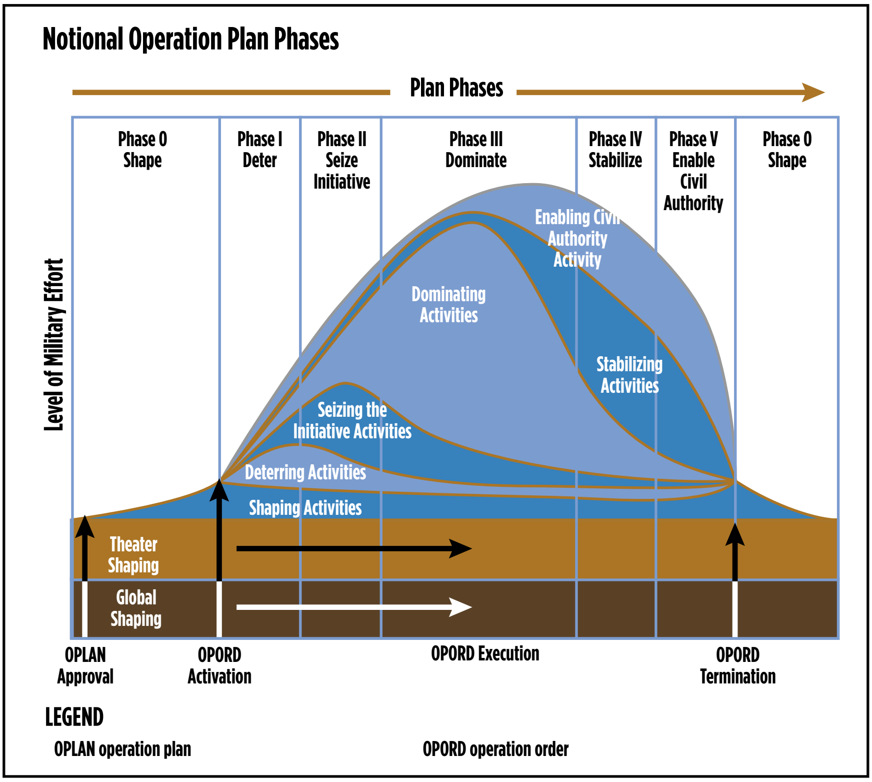
Contracting Phases—Complementing Warfighter Strategy

Contingency contracting planning must complement and seamlessly integrate with the DoD and Combatant Command APEX planning process. On the surface, the two processes appear distinctly different, with phasing graphics exhibiting dissimilar phasing models and activity descriptions within each phase. Examination of each model reveals

that the two processes are complementary, but care must be taken to ensure that contracting phasing supports and is parallel with operational planning.

The DoD deliberate planning process generally includes six phases, although the number and types of phases are contingent upon the characteristics of the joint operation. For instance, a combat operation will be phased differently than a humanitarian relief operation. JP 5-0 describes the notional phasing construct (Figure 2) as follows: Phase 0 (Shape) includes normal and routine military activities as well as security cooperation activities that are contained within the theater campaign plan (TCP). The TCP includes steady state operations and activities intended to promote international legitimacy and cooperation with friends and allies, while dissuading adversaries. Phase I (Deter) includes those activities that demonstrate "joint force capabilities and resolve" in response to an adversary's undesirable actions. Actions

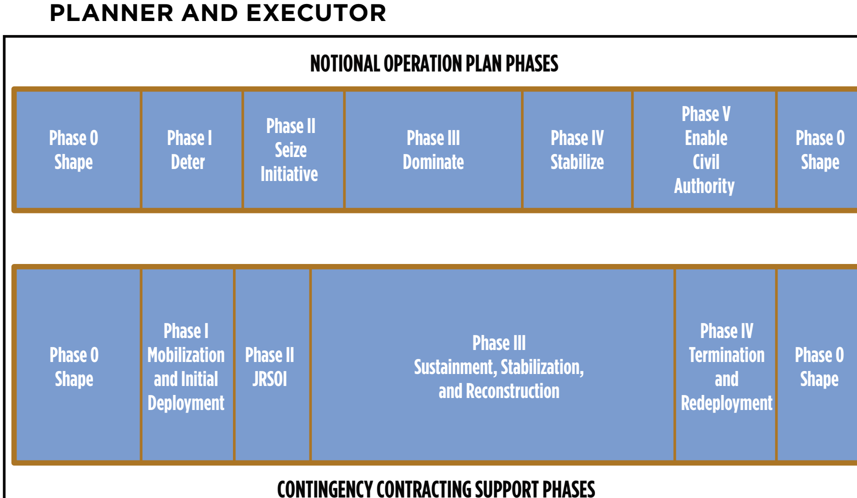
FIGURE 2. WARFIGHTER'S NOTIONAL OPERATIONAL PLAN PHASES



Source. (CJCS, 2011)

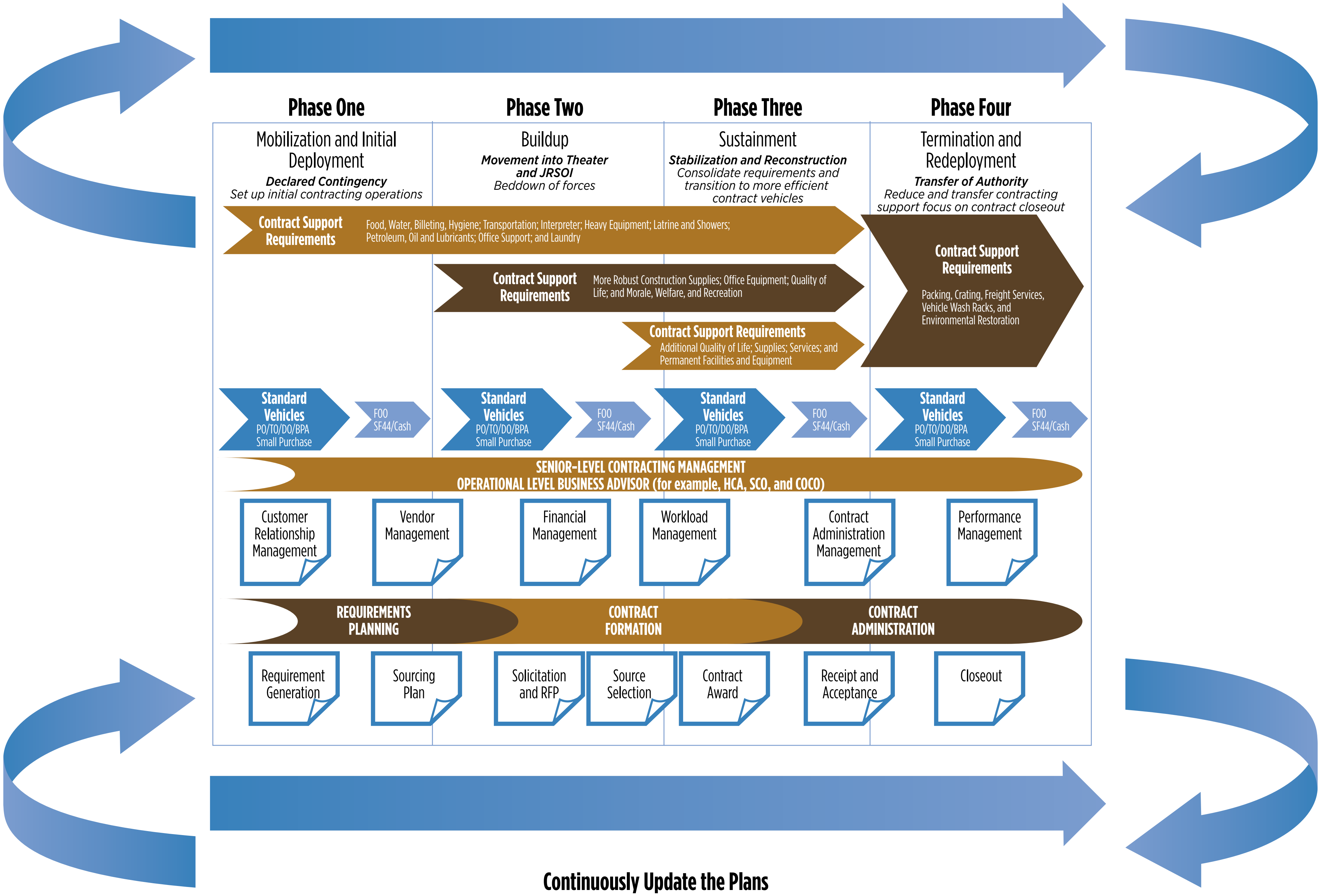
include preparation for deployment, deployment, and shows of force designed to influence an adversary's decision-making process. Phase II (Seize Initiative) begins the "application of appropriate joint force capabilities" to "delay, impede, or halt an adversary's initial aggression." This phase sets the conditions for the successful implementation of the Phase III (Dominate) phase. Phase III includes actions designed to "break the enemy's will . . . or, in noncombat operations, to control the operational environment." Phase IV (Stabilize) is "required when there is no fully functional legitimate civil governing authority," and joint forces must perform limited local governance and other activities to allow for a restoration of stability and a return to normalcy. This phase may require joint force cooperation and coordination with intergovernmental organizations, nongovernmental organizations, or other civilian agencies. Phase V (Enable Civil Authority) includes the provision of "joint force support to legitimate civil governance" in theater as well as assistance with the provision of essential services to local populations. It usually includes redeployment operations, especially of combat forces, as well as the planning for transition back to Phase 0 or steady-state operations. Figure 3 illustrates the notional operation plan phases (CJCS, 2011, pp. III-41–III-44).

FIGURE 3. THREE-TIER MODEL: TIER THREE, INTEGRATED PLANNER AND EXECUTOR



Note. JRSOI = Joint Reception, Staging, and Onward Integration

FIGURE 4. CONTRACTING PHASE ZERO: PLAN, EXERCISE, REHEARSE, AND SYNCHRONIZE



Note. BPA = Blanket Purchase Agreement; COCO = Chief of Contracting Office; DO = Delivery Order; FOO = Field Ordering Officer; HCA = Head of Contracting Activity; JRSOI = Joint Reception, Staging and Onward Integration; PO = Purchase Order; RFP = Request for Proposal; SCO = Senior Contracting Official; SF-44 = Standard Form 44; TO = Task Order.

OPEN TO SEE FIGURE

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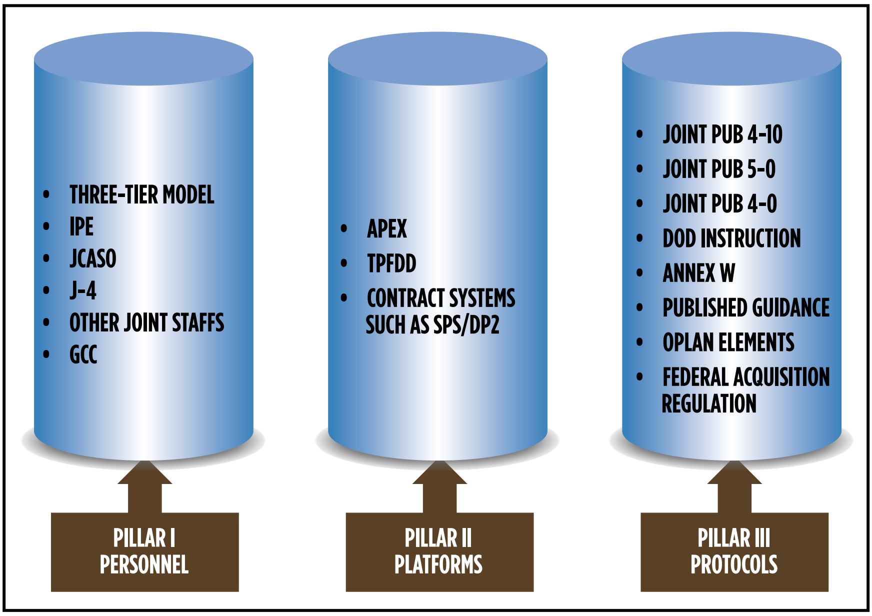
Since NDAA 2008, contracting has utilized five support phases. Phase Zero (Figure 4) is the planning, exercise, and rehearsal phase. During this phase, contingency contracting planners work with combatant command staffs in the deliberate planning process to develop the Annex W for each campaign and operations plan. Exercising and rehearsing these plans is imperative to ensure they meet the warfighter's expectations and correspond with Phase 0 of the deliberate planning process. Phase I is deployment, during which initial contracting operations and relationships are established, especially to provide basic life support requirements for arriving personnel. It corresponds roughly with the first half of the warfighter's Phase I (Deter). The contracting Phase II is joint reception, staging, onward movement, and integration. This phase includes the arrival of the main body of deploying forces and their equipment. It requires the establishment of more robust contracting initiatives, including expanded life support requirements and temporary construction to support the deployed force and corresponds with the warfighter's Phase I (Deter), as well as elements of Phase II (Seize Initiative). Phase III (Sustainment) provides contracting support from the completion of the build-up phase until the beginning of the redeployment of the force. It also includes stability and reconstruction. This contingency contracting phase corresponds with the warfighter's Phase II (Seize Initiative), Phase III (Dominate), Phase IV (Stabilize), and portions of Phase V (Enable Civil Authority). The contracting Phase IV is termination and redeployment, and includes activities that support the "pressure and urgency to send the deployed forces home." It also includes close-out of existing contracts as well as establishing contracts for follow-on forces, such as United Nations peacekeepers (Defense Procurement, 2012, pp. 111–121).

DoD Directive (DoDD) 3020.49 mandates the coordination and synchronization of contracting with broader warfighter OPLANs (DoD, 2009). As Figure 4 illustrates, contracting phasing does not correspond exactly with the warfighter's phasing plan. This lack of correspondence can lead to misunderstanding, lack of communication within the planning staff, and a failure of coordination and synchronization. The authors strongly suggest that contracting personnel revise the phasing plan to more closely correspond with the JP 5.0 phasing construct.

Phase Zero and Mandatory Pillars for Strategic Contracting Integration

As defined previously, Phase Zero is the planning, exercising, and rehearsal phase of military operations—properly establishing and vetting the contracting plan prior to an actual event or crisis. To function effectively within the established and existing military deliberate and contingency planning framework, the IPE and associated functions must be designed within three main pillars: personnel, platforms, and protocols (Figure 5). Failure to integrate contracting with all of the three primary pillars will result in suboptimization or outright contract support and/or mission failure (Yoder, 2010).

FIGURE 5. MANDATORY PILLARS FOR INTEGRATIVE SUCCESS



Note. APEX = Adaptive Planning & Execution System; GCC = Global Combatant Commander; IPE = Integrated Planner and Executor; JCASO = Joint Contingency Acquisition Support Office; PD2 = Procurement Defense Desktop; SPS = Standard Procurement System; TPFDD = Time Phased Force Deployment Data

The first pillar, personnel, should be addressed by implementing the TTM and particularly the IPE. The second pillar, platforms, is addressed by integrating contracting throughout all phases of military operations and into the existing warfighters' platform for planning and execution—the APEX. Additionally, it must be embedded with other

APEX-complementary platforms, such as the Time Phased Force and Deployment Data (TPFDD) system. The third pillar, protocols, represents the existing or desirable set of rules and procedures, including sound business, planning, and military doctrine that govern the planning and execution of the contracting plan within the broader OPLAN. Figure 5 highlights the three pillars and associated elements.

Protocols include, but are not limited to, the strategic planning guidance established by the GCC; strategic purchasing guidance and mandates; JP 4-10, JP 5-0, JP 4-0, *Doctrine for Logistic Support of Joint Operations* (CJCS, 2000), and other doctrinal publications; and associated mandates for constructing and implementing Annex W for each unique OPLAN. Additionally, acquisition- and contracting-specific laws, regulations, and guidance must be utilized including, but not limited to, the Federal Acquisition Regulation (2012) and the Defense Federal Acquisition Regulation Supplement (Defense Procurement, 2013), as well as any specific military service acquisition regulations.

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Annex W must include all of the key elements for mission success and address the three mandatory pillars for integrative success: personnel, platforms, and protocols.

The Integrated Planner and Executor within Strategic Planning, APEX Products, and Annex W

Joint strategic planning products include, but are not limited to, GCC estimates, base plans, OPLANs, CONPLANs, warning orders, planning orders, alert orders, operation orders (OPORD), execute orders, fragmentary orders, and deployment orders, along with all annexes including the newly mandated Annex W. These products are alien to most contracting and acquisition professionals because, traditionally, contracting and acquisition personnel have not played a key role in the production or management of these critical documents. The GAO recently conducted an audit of 39 OPLANs requiring an integrated Annex W, and found that only four operational contracting plans had been produced (GAO, 2011).

FIGURE 6. MINIMUM ELEMENTS INCLUDED IN AN INTEGRATED ANNEX W

1.	Mission statement—from the OPLAN or OPORD
2.	Primary and secondary customers
3.	Anticipated requirements (in relative time-phase)
4.	Forces deploying in sequence and duration
5.	Operational locations
6.	Lead service
7.	Organization structure (Head of Contracting Activity, Joint Acquisition Review Board, etc.)
8.	Supported and supporting relationships
9.	Command and control relationships
10.	Procedures for appointing, training, and employing field ordering officers, contacting officer representatives, disbursing agents, and government purchase card holders
11.	Procedures for defining, validating, processing, and satisfying customer requirements
12.	Procedures for budgeting receipt of supplies/services and payments to vendors
13.	Procedures for closing out contracting operations and redeployment
14.	Supplies and services anticipated locally, local customs, laws, taxes, SOFAs, host nation support, Acquisition Cross-Service Agreements, vendor base, etc.
15.	Infrastructure, office location, security measures, kits, etc.
16.	Security requirements and procedures for contracting and contractor personnel
17.	Standards of support—processing times, turn-around-time, Procurement Acquisition Lead Time, and reporting
18.	Specific statutory/regulatory constraints or exemptions, special authorities, and programs
19.	Relief in place/transfer of authority
20.	Contractor restrictions (movement, basing, etc., time-phase specific)
21.	Guidance on transferring Logistics Civil Augmentation Program support to theater support contracts by function and/or phase of the operation
22.	Special authorities and programs (Commanders' Emergency Response Program–Counterinsurgency)
23.	Postcontract award actions (management, closeout, de-obligation, etc.)
24.	Contractor support, civil augmentation programs
25.	Mandated solicitation and contract provisions
26.	Human trafficking mandates, indemnity, and Military Extraterritorial Jurisdiction Act provisions

Source: (Yoder, 2010)

Clearly, given the defined content of Annex W, the contracting at the strategic IPE level must be included in all phases of planning and in the production of key APEX products. Annex W must include all of the key elements for mission success and address the three mandatory pillars for integrative success: personnel, platforms, and protocols. The integrated Annex W must include, at a minimum, those elements deemed essential for mission accomplishment, while addressing cost and affordability within the overall OPLAN. The contents include, but are not limited to, as indicated in Yoder (2010), the 26 elements shown in Figure 6.

Without a comprehensive planning capability, most missions will be negatively affected. Clearly, the IPE, properly positioned within the planning community, can better create and assess the Annex W capabilities within the three main pillars—personnel, platforms, and protocols—to allow for future success.

Conclusions

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To date, contracting has not been fully integrated into military planning and execution. Some significant strides have been made to better assimilate contracting at the strategic level, including Dr. Jacques Gansler's (2007) report, *Urgent Reform Required*, and the recently published doctrine contained in JP 4-10 (CJCS, 2008). However, despite the push toward better integration, including the newly formed JCASO, the DoD still lacks a manifest comprehensive planning and executing capability, as evidenced most recently in the final report of the Commission on Wartime Contracting in Iraq and Afghanistan (2011).

The lack of planning and sound contract integration at the strategic level leads to loss of efficiencies, lack of effectiveness, and, in many cases, outright fraud of the executing participants as highlighted in the 2011 report of the Commission on Wartime Contracting in Iraq and Afghanistan.

The functions of the IPE and mandates for OCS (CJCS, 2008), including generating a thoroughly vetted Annex W, are so massive that the Services have recently contracted out, or outsourced, some of the requirement (Yoder, 2011). However, outsourcing this critical function may only make matters worse, in that key decisions will be left in the purview of nongovernment personnel, including decisions of further contracting, along with other possible conflicts of interest and potential for corruption.

The authors contend that the best means to accomplish integration into existing war planning systems is by congressionally mandating, authorizing, and funding (via appropriation) the IPE positions at the flag and senior executive service levels within Service structures. In the short term, the authors recommend that JCASO have more status and capability within GCC and Service staffs, particularly in assisting the GCC staff to establish, monitor, and manage Annex W within the APEX framework. This will require greater engagement capability than currently exists. In the long-term, the authors recommend Congressional approval and funding of IPE positions organically within the GCC staff, providing them with direct authority for the development, review, and employment of Annex W. This greater presence and authority at the IPE level within the GCC staff represents the level of bona fide commitment to solve a long-standing problem that, without correction, will continue to fester and plague Service chiefs, military commanders, Congress, and taxpayers. Additionally, fully aligning and integrating the contracting community's processes with the joint community planning system is imperative. Failure to do so may result in lack of communication, lack of synchronization of support plans, and marginalization of contracting personnel within the GCC planning staff. Implementing PZCO planning through sound public policy, congressional authorization and funding, and the Services' commitment to fully integrate contracting within the three pillars—personnel, platforms, and protocols—is the proactive move toward success.

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Keywords: *Obligation and Expenditure, Funding and Requirements, Variances, Causal Factors, Standard Deviation, Continuing Resolution Authority (CRA)*

The Challenges in Meeting OSD's Obligation and Expenditure Rate Goals: *A Closer Look at Potential Causal Factors, Their Groupings, and How They Modulate*

Col Robert L. Tremaine, USAF (Ret.), and Donna J. Kinnear-Seligman

Managing an acquisition program in the DoD is a complicated process. The turbulence created by funding instability can make it even more difficult. Nonetheless, to help program offices maintain their overall funding execution pace, the Office of the Secretary of Defense (OSD) instituted Obligation and Expenditure rate goals over two decades ago. For numerous reasons, acquisition program managers have found it difficult to meet established Obligation and Expenditure rate goals. For purposes of this article, and based on Defense Acquisition University and OSD subject matter expertise, the authors looked more closely at the potential causal factors that could be interfering with the achievement of these goals.

Image designed by Diane Fleischer »


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Several months ago, Dr. Nancy Spruill, director of Acquisition Resources and Analysis, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, solicited support from the Defense Acquisition University (DAU) to help uncover the causal factors that could be interfering with the attainment of OSD's Obligation and Expenditure rate goals. To learn more about the intervening obstacles, DAU, with assistance from OSD, developed a comprehensive survey that queried experienced and high-level DoD personnel involved in a weapon program's decision chain. The data might also indicate the prevalence of any significant variances among the factors that could be undermining program execution itself. Results of the study (Higbee, Tremaine, Seligman, & Arwood, 2013) were presented to Assistant Secretary of Defense for Acquisition Katrina McFarland and other senior OSD personnel.

Research Methodology

Two hundred and twenty-nine DoD personnel responded to this survey. The respondents were comprised of program office personnel (program managers, deputy program managers, budget and financial managers, and contracting officers); program executive officers and their chief financial officers; and a variety of senior staff at OSD including Headquarters Financial Management senior staff and Senior Acquisition Executive (SAE) staff (Table 1). Because several functional areas reflected lower response rates, a more detailed analysis of the causal factors was restricted to an aggregate sample size given the confidence levels required to draw any inferences or conclusions.

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TABLE 1. INDIVIDUAL RESPONDENT GROUPS

Survey Respondent Details									
	ACAT Levels			Respondent Groups			Totals		
Respondent Distribution[a]	I	II	III	Program Office[b]	PEO[c]	Senior Staff[d]	Responses	Queried	Response Rate
Total	91	28	23	142	63	24	229	698	33%

[a] Includes sampling from all DoD Components and several Defense Agencies

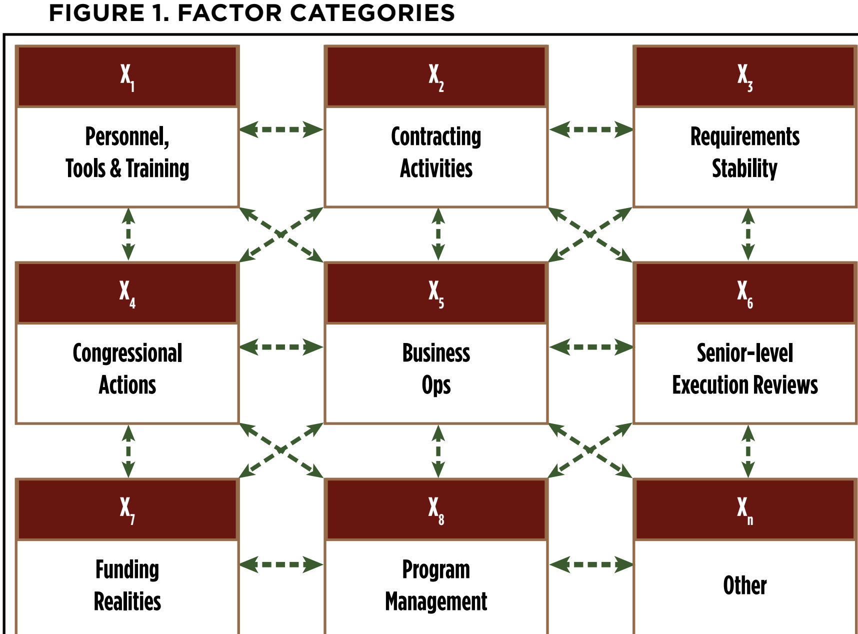
[b] Program managers, deputy program managers, business-financial management (BFM) managers, deputy BFM managers, and contracting officers

[c] Program executive officers (PEO), deputy PEOs, and their chief financial officers

[d] Headquarters, Financial Management and Senior Acquisition Executive staff

Respondents ranked the impact of 64 factors under nine categories (Figure 1). The researchers then assessed the rankings using a top box (TB) three methodology (i.e., the percentage of 5, 6, and 7 responses on a Likert-like scale from 1–7). Since the frequency of occurrence for some factors could also be contributing to the interference, the researchers included an additional selection (e.g., daily, weekly, monthly, etc.) to isolate any potential ignition areas for any factor.

FIGURE 1. FACTOR CATEGORIES

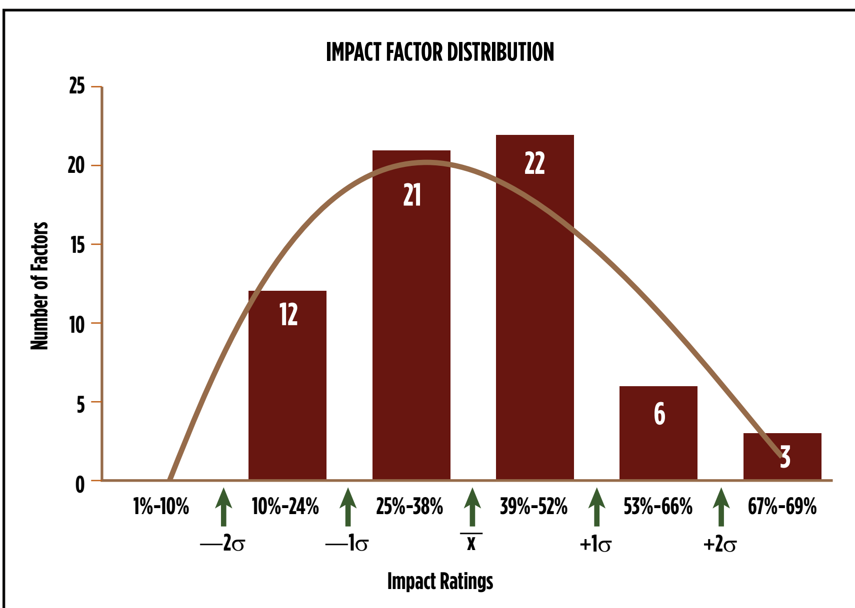


Discussion

Factor Distribution

Figure 2 shows the distribution of all 64 factors assessed. *Three* factors reported an impact rating of two standard deviations above the mean (denoted by $+2\sigma$); *six* factors reported an impact rating of one standard deviation above the mean (denoted by $+1\sigma$); and *22* factors rose above an average impact rating (denoted by $\bar{x}$). The remaining 33 factors fell below $\bar{x}$.

FIGURE 2. RESPONDENT HISTOGRAM



Nineteen of the *22* factors measured for frequency of occurrence resulted in an impact rating above 39 percent. Sometimes, just one occurrence of that factor appeared to have a significant impact.

Causal Factors Rank Ordered

Table 2 lists the relative ranking of all 64 factors in the context of TB in descending order. This ranking provides a comprehensive view of all factors although the remaining discussion in this article addresses only the factors above $\bar{x}$. One particular factor, "Unrealistic, overly optimistic spend plans" (F^{10}), is important to note since it serves as a

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written forecast of a program's funding needs and initially establishes Obligation and Expenditure projections. However, spend plans are also subjected to so many real world eventualities that updating them can become a full-time job.

Factors and Respondent Groups

Figure 3 accounts for the 31 factors above the mean and by respondent group as depicted in Table 1. The 31 factors were the only ones further evaluated in this study unless a factor shifted above $\bar{x}$ after a more detailed correlation delineation (e.g., Acquisition Category [ACAT]) levels, military components, position, etc.). Unexpectedly, the individual factors showed widespread perception disparities among the respondent groups for the factors that fell below +2σ. After analyzing the specific individual factors among all the respondent groups, seven of the 31 factors had an unusually large σ. As a result of these conspicuous gaps, the authors turned to the qualitative data and watched for any strong correlations (e.g., positive quantitative correlation coefficients (r) > 0.7) to better understand the reasons for the differences as well as the influence of any intervening and/or moderating factor couplings. The remaining discussion addresses the 31 impact factors in descending order from highest to lowest.

Factors Ranked Two Standard Deviations Above the Mean (+ 2σ)

In Figure 3, Late release of full obligation/budget authority due to Continuing Resolution Authority (CRA) (F^1), Contract negotiations' delays (F^2), and Contract award delays (F^3) all rose above 2σ where 67 percent or more of the respondents claimed they had the highest adverse impact of all factors measured. The occurrence of CRA had the most significant negative impact to Obligation and Expenditure rates. It also had one of the smallest variances (σ) among the respondent groups. Even with the expectation that CRA might prevail and the subsequent planning that followed for such a likely event, many PMs pointed to an overly conservative and slow internal vetting process posture that created additional obstacles in meeting OSD goals. In their responses to qualitative questions, several PMs recommended using some sort of "CRA variable" to temporarily offset the consequences of CRA if the required funds were not released as originally projected. Next in rank order were contract negotiations and contract award delays. The respondents emphasized that DoD could fix the problem more readily since unlike CRA, these factors were under internal control. When asked what could be done

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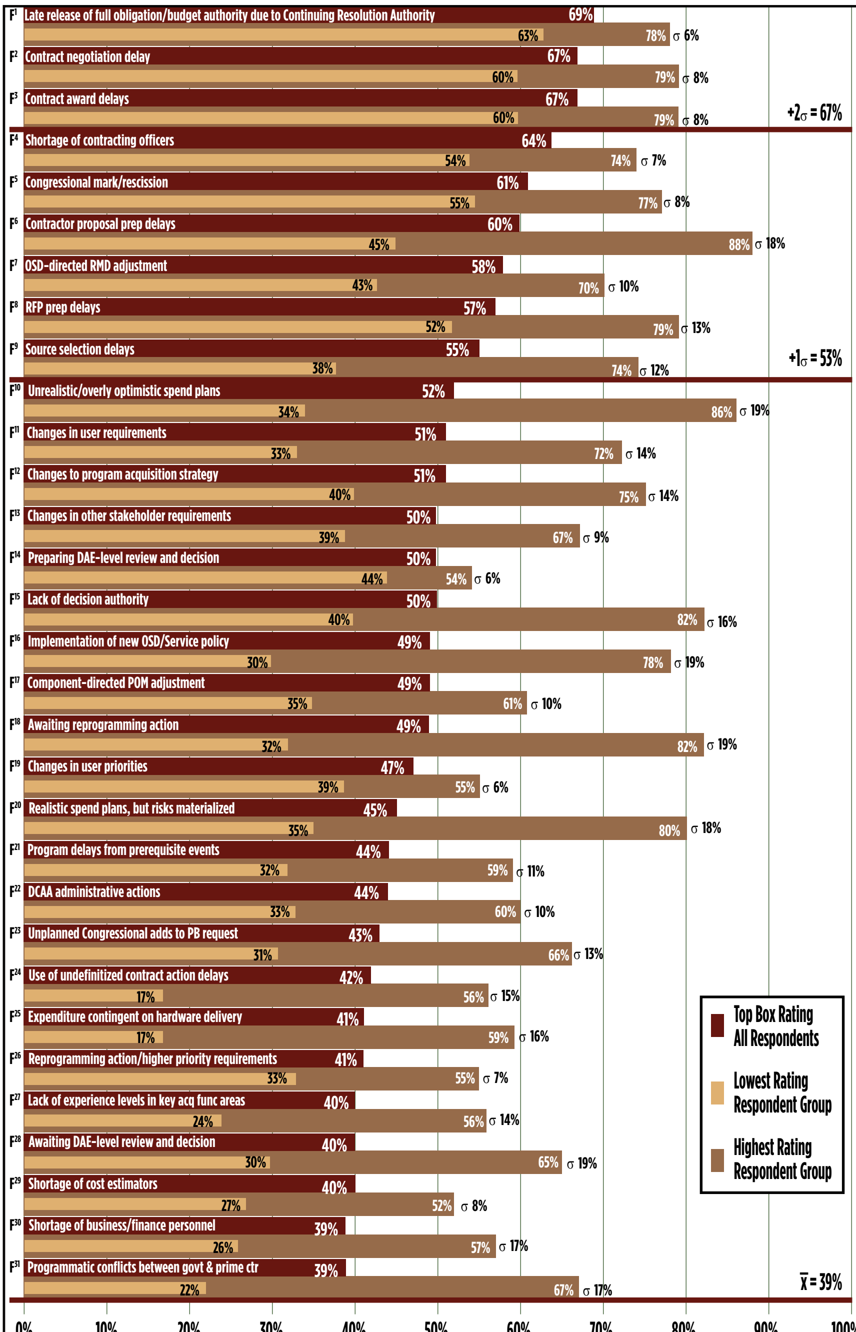
TABLE 2. IMPACT FACTOR RATINGS IN AGGREGATE DESCENDING ORDER

	Factors Rated by Adverse Impact	TB	$\bar{x}$	σ	
F^{1}	Late release of full obligation budget authority due to Continuing Resolution Authority (CRA)	69%	5.29	2.41	
F^{2}	Contract negotiation delays	67%	5,06	2.59	
F^{3}	Contract award delays	67%	5.00	2.56	$+2\sigma = 67\%$
F^{4}	Shortage of contracting officers	64%	4.79	2.58	
F^{5}	Congressional mark/rescission	61%	4.87	2.65	
F^{6}	Contractor proposal prep delays	60%	4.87	2.59	
F^{7}	OSD-directed Resource Management Decision (RMD)	58%	4.50	2.63	
F^{8}	Request for Proposal (RFP) prep delays	57%	4.63	2.46	
F^{9}	Source selection delays	55%	4.44	2.53	$+1\sigma = 53\%$
F^{10}	Unrealistic, overly optimistic spend plans	52%	4.30	2.44	
F^{11}	Changes in user requirements	51%	4.16	2.43	
F^{12}	Changes to program acquisition strategy	51%	4.41	2.52	
F^{13}	Changes in other stakeholder requirements	50%	4.32	2.34	
F^{14}	Preparing Defense Acquisition Executive (DAE)-level review and decision	50%	4.15	2.18	
F^{15}	Lack of decision authority at expected levels	50%	4.22	2.52	
F^{16}	Implementation of new OSD/Service policy	49%	4.20	2.59	
F^{17}	Component-directed Program Objective Memorandum (POM) adjustment	49%	4.26	2.51	
F^{18}	Awaiting reprogramming action	49%	4.23	2.44	
F^{19}	Changes in user priorities	47%	4.00	2.38	
F^{20}	Realistic spend plans, but risks materialized	45%	4.00	2.21	
F^{21}	Program delays from additional development, testing, or other prerequisite events	44%	4.09	2.35	
F^{22}	Defense Contract Audit Agency (DCAA) administrative actions	44%	3.92	2.61	
F^{23}	Unplanned Congressional adds to Program Baseline (PB) request	43%	3.90	2.41	
F^{24}	Use of undefinitized contract action delays	42%	3.73	2.56	
F^{25}	Expenditure contingent on hardware delivery	41%	3.92	2.41	
F^{26}	Loss of funding through reprogramming action to higher priority requirements to program executive officer (PEO) portfolio	41%	3.89	2.46	
F^{27}	Lack of experience levels in key acquisition functional areas	40%	3.90	2.30	
F^{28}	Awaiting DAE-level review and decision	40%	3.50	2.42	
F^{29}	Shortage of cost estimators	40%	3.67	2.37	
F^{30}	Shortage of business/finance personnel	39%	3.66	2.32	
F^{31}	Programmatic conflicts between government and prime contractor	39%	3.66	2.32	$\bar{x} = 39\%$

	Factors Rated by Adverse Impact Continued	TB	$\bar{x}$	σ
F32	Preparing Service Acquisition Executive/Component Acquisition Executive (SAE/CAE)-level review and decision	38%	3.74	2.02
F33	Delays in contractor payment due to late invoices	37%	3.67	2.35
F34	Unobligated prior year funding not adequately factored	36%	3.57	2.23
F35	Component Comptroller Withhold	35%	3.58	2.34
F36	Defense Contract Management Agency (DCMA) administrative actions	35%	3.42	2.36
F37	Redirection of contractor efforts	35%	3.47	2.23
F38	OSD Comptroller Withhold	34%	3.43	2.37
F39	Shortage of technical/engineering/test personnel	34%	3.51	2.17
F40	Shortage of auditors	33%	3.17	2.43
F41	Slower burn rate than expected due to unfavorable Schedule Performance Index	33%	3.25	2.14
F42	Awaiting SAE/CAE-level review and decision	32%	3.33	2.30
F43	SAE/CAE/Component-directed reprogramming	32%	3.27	2.30
F44	Rescission	32%	3.16	2.46
F45	Changes in systems specs	31%	3.30	2.03
F46	Tenure of program manager (PM) and others in key positions	31%	3.11	2.18
F47	Holding award/incentive fees in commitment for future obligation	29%	3.23	2.35
F48	Inadequate training	29%	3.29	2.13
F49	Shortage of managers	28%	3.10	2.17
F50	Insufficiently planned Overseas Contingency Operations (OCO) funding	27%	3.07	2.27
F51	Shortage of staff	26%	2.99	2.12
F52	Contractor rework	26%	3.00	2.14
F53	Deferred payments for scheduling earning fees, progress payments/performance-based payments	25%	3.08	2.20
F54	Effect of contract type on outlay rates	24%	2.99	2.17
F55	Materiel/Systems Command Comptroller Withhold	24%	2.71	2.17
F56	Awaiting PEO-level review and decision	24%	2.80	2.01
F57	Termination liability	22%	2.72	2.17
F58	Insufficient workplace tools/apps	22%	2.82	2.01
F59	PEO-directed programming	21%	2.83	2.10
F60	Slower burn rate than expected due to favorable Cost Performance Index	21%	2.77	1.95
F61	PEO Withhold	20%	2.39	1.99
F62	Preparing PEO-level review and decision	20%	2.66	1.53
F63	Production line issues	19%	2.82	2.08
F64	Labor disputes	10%	1.89	1.64

$-1\sigma = 25\%$

FIGURE 3. IMPACT RATINGS ABOVE $\bar{x}$ IN AGGREGATE DESCENDING ORDER WITH RESPONDENT GROUP LOW AND HIGH RATINGS



to reduce the adverse effects of all three factors, the respondents recommended the "inclusion of more risk mitigation into contract award planning, more realistic timelines, more realistic plans, greater funding stability, reduction in bureaucratic obstacles, more synchronized internal processes, and better aligned accounting systems."

Factors Ranked One Standard Deviation Above the Mean (+1σ)

This next line of demarcation (Figure 3, factors F^4–F^9) included many contracting-related factors (i.e., Shortage of contracting officers (F^4), Contractor proposal prep delays (F^6), Request for Proposal (RFP) prep delays (F^8) and Source selection delays (F^9). Nearly all the factors showed the emergence of a more alarming $\boldsymbol{\sigma}$ between the individual respondent groups—as high as 18 percent in one case (i.e., Contractor proposal prep delays [F^6]). For this particular factor, procurement contracting officers (PCO) reported the highest impact, while PMs ranked it as the lowest. Senior staff cited that Shortage of contracting officers (F^4) created the highest impact, while PCOs reported it had the lowest impact. With a 7 percent $\boldsymbol{\sigma}$, it was the lowest among all six factors in this grouping.

6

Given that six of the top nine factors were contract-specific factors that ranked above $+1\boldsymbol{\sigma}$ (Figure 3), it came as little surprise to see so many reinforcing comments surface.

- "Lack of experienced and qualified contract specialists . . . ."
- "Alarmingly low personnel qualified . . . many unsure/lack guidance and experience . . . ."
- "Significantly stressed with overtime to complete all contracting actions prior to close of fiscal year."
- "Inadequate training . . . inordinate number of interns with very low experience in all career fields."
- "Lack of sufficient legal personnel trained in Acquisition."
- "Loss in brain trust and skill to develop complete, clear SOWs [Statements of Work] using proactive contract language."
- "SOW writing and the teaching of SOW writing classes is greatly left to contractors or support contractors, resulting in unclear language."

The highest frequency of occurrence was also associated with contracting-related factors (Figure 3). By far, the aggregate respondents rated Shortage of contracting officers (F^4) as the single highest factor among all 22 factors measured for frequency. Because the contracting activity timeline generally has lengthy durations, any disruption appears to have an unmistakable impact on contract award. Shortage of contracting officers (F^4) was seen as having the most significant impact. Several respondents said "multiple contracting actions were having compounding consequences."

The two remaining factors above $+1\boldsymbol{\sigma}$ Congressional mark (F^5) and OSD-directed RMD adjustment (F^7), had very low frequency of occurrences, but still reported a very high impact similar to CRA. When combining these with F^4, all three appear to be a strong antecedent force (or moderating factor) to the already time-consuming chain of contracting actions.

Factors Ranked Above $\bar{x}$

This final grouping (Figure 3, factors F^{10}–F^{31}) accounted for the remaining 22 impact factors. Perception polarities persisted, especially between two respondent groups—senior staff outside the program office and PMs inside program offices. For PMs in every case except one (i.e., Component-directed POM adjustment [F^{17}]), the impact factors ranked well below $\bar{x}$. In sharp contrast, senior staff, in every case except one (i.e., Component-directed POM adjustment [F^{17}]), stated the majority of the top 31 factors had the largest impact—or close to it—among all respondent groups.

Even though the remaining impact factors above $\bar{x}$ are still significant, the researchers shifted the focus to the presence of any strong correlations since factor couplings could be having a moderating effect and require a closer look.

Factors That Correlate

Table 3 summarizes the strongest and weakest factor correlations for all respondents queried. Several strong correlations surfaced for factors above $\bar{x}$. Changes in user requirements (F^{11}) and Changes in user priorities (F^{19}) were very strongly correlated. In three specific instances, two factors above $\bar{x}$ were very strongly correlated with three factors that fell below $\bar{x}$: Lack of experience levels in key acquisition functional areas (F^{27}) and Inadequate training (F^{48}); Lack of experience levels in key acquisition functional areas (F^{27}) and Tenure of PM and others in key positions (F^{46}); and DCMA administrative actions (F^{36}) and DCAA administrative actions (F^{22}). Three contract-related factors (F^{4}, F^{8}, and F^{9}) showed weaker correlations than expected. Whether a factor had a weak correlation doesn't mean it had any less importance, but any course of action intended to mitigate the presence of any impact factor strongly correlated with another should be weighed more heavily in any recommended action. For example, the turnover of PMs could be part of the experience quotient.

Factor Plotting

The researchers generated a scatter plot diagram (Figure 4) that punctuated how the 31 factors fluctuated between impact and frequency of occurrence. In some cases, the impact of certain factors occurred with low frequencies of occurrence. In other cases, the frequency of occurrence compounded the impacts.

TABLE 3. FACTOR CORRELATION COUPLING

r	*r*²	Strongest Correlation Coefficients
		Experience, Training, and Tenure:
.84	71%	F^{27} Key acquisition experience levels and F^{48} Inadequate training
.78	61%	F^{27} Key acquisition experience levels and F^{46} Tenure of PM and other key positions
		Administrative Actions:
.81	76%	F^{36} DCMA and F^{22} DCAA
.82	67%	F^{11} User requirements and F^{19} User priorities
.70	49%	F^{19} User priorities and F^{13} Stakeholder requirements
		Contract-related Activities:
.71	50%	F^{6} Contractor proposal delay and F^{2} Contract negotiations delays
.70	49%	F^{3} Contract award delays and F^{2} Contract negotiations delays

Weakest Correlation
F^{1} Late release of full obligation/budget authority due to CRA
F^{4} Shortage of contracting officers
F^{5} Congressional mark/rescission
F^{7} OSD-directed RMD adjustment
F^{8} RFP prep delays
F^{10} Unrealistic/overly optimistic spend plans
F^{12} Changes to program acquisition strategy
F^{15} Lack of decision authority
F^{16} Implementation of new OSD/Service policy
F^{17} Component-directed POM adjustment
F^{18} Awaiting reprogramming action
F^{20} Realistic spend plans, but risks materialized
F^{21} Program delays from prerequisite events
F^{23} Unplanned Congressional adds to PB request
F^{25} Expenditure contingent on hardware delivery
F^{26} Loss of funding through reprogramming
F^{29} Shortage of cost estimators
F^{30} Shortage of business/finance personnel
F^{31} Programmatic conflicts between government and prime contractor

The higher the %, the stronger the direction and strength of the linear relationship between the variables

Factors # 1 – 3 $\geq +2\sigma$;

Factors # 4 – 9 $\geq +1\sigma$

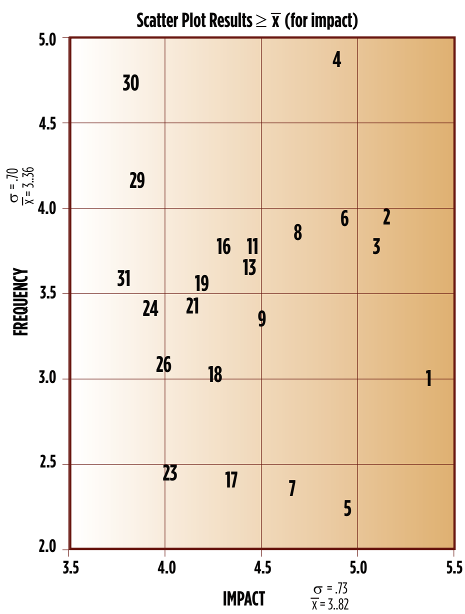
Factors # 10 – 31 $\geq \bar{x}$

The research data results were rebased to a Likert-like scale for plotting the frequency and adverse impact response averages. The researchers included Factors F^{29}–F^{31} in Figure 4 because they only fall slightly below $\bar{x}$.

For the relationships that were co-linear (e.g., the most strongly correlated depicted in Table 3), the researchers explored whether they also behaved as strong predictors across the sample population. After investigating *t*-ratios (used with ACAT Level factors) and beta-weights (used

for the sample population), the researchers determined the relationships were not significantly co-linear enough to substantiate causation. Consequently, there was no merit in running any further regression that analyzed the factors as predictors. However, the researchers conducted another set of tests by modulating certain respondent demographics and holding constant.

FIGURE 4. SCATTER PLOT OF IMPACT FACTORS WITH FREQUENCY



1 Late release of full obligation/budget authority due to CRA
2 Contract negotiations delays
3 Contract award delays
4 Shortage of contracting officers
5 Congressional mark
6 Contractor proposal prep delays
7 OSD-directed RMD adjustment
8 RFP prep delays
9 Source selection delays
10 Unrealistic/overly optimistic spend plans[1]
11 Changes in user requirements
12 Changes to program acquisition strategy[1]
13 Changes in other stakeholder requirements
14 Preparing DAE-level review and decision[1]
15 Lack of decision authority at expected levels[1]
16 Implementation of new OSD/Service policy
17 Component-directed POM adjustment
18 Awaiting reprogramming action
19 Changes in user priorities
20 Realistic spend plans, but risks materialized[1]
21 Program delays from additional development, testing, or other prerequisite events
22 DCAA administrative actions[1]
23 Unplanned Congressional adds to PB request
24 Use of undefinitized contract action delays
25 Expenditure contingent on hardware delivery[1]
26 Loss of funding through reprogramming action to higher priority requirements to PEO portfolio
27 Lack of experience levels in key acquisition functional areas[1]
28 Awaiting DAE-level review and decision[1]
29 Shortage of cost estimators
30 Shortage of business/finance personnel
31 Programmatic conflicts between government and prime contractor

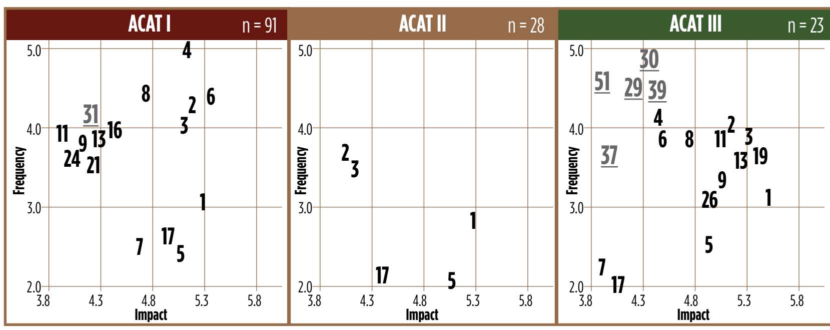
≥ $+2\sigma$
≥ $+1\sigma$
≥ $+\bar{x}$

[1] Factor listed by rating of adverse impact, but not plotted by frequency. Frequency data not collected.

Factor Plotting—Modulating ACAT Levels

Figure 5 shows how the factor rankings changed after isolating ACAT levels.

FIGURE 5. FACTOR RATINGS ≥ $\bar{x}$ ACAT LEVEL



MODULATION OF FACTORS	MODULATION OF FACTORS	MODULATION OF FACTORS
Factor Decrease:	**Factor Decrease:**	**Factor Decrease:**
F^{18} Awaiting reprogramming action	F^{2} Contract negotiation delays	F^{16} Implementation of new OSD/Service policy
F^{19} Changes in user priorities	F^{3} Contract award delays	F^{18} Awaiting reprogramming action
F^{23} Unplanned Congressional adds to PB request	F^{4} Shortage of contracting officers	F^{19} Changes in user priorities
F^{26} Loss of funding through reprogramming action to higher priority requirements to PEO portfolio	F^{6} Contractor proposal prep delays	F^{21} Program delays from prerequisite events
Factor Increase:	F^{7} OSD-directed RMD adjustment	F^{23} Unplanned Congressional adds to PB request
F^{31} Programmatic conflicts between government and prime contractor	F^{8} RFP prep delays	F^{24} Use of undefinitized contract action delays
	F^{9} Source selection delays	**Factor Increase:**
	F^{11} Changes in user requirements	F^{29} Shortage of Cost Estimators
	F^{13} Changes in other stakeholder requirements	F^{30} Shortage of business/finance personnel
	F^{16} Implementation of new OSD/Service policy	F^{37} Redirection of contractor efforts
	F^{18} Awaiting reprogramming action	F^{39} Shortage of technical/engineering/testing personnel
	F^{19} Changes in user priorities	F^{51} Shortage of staff
	F^{21} Program delays from prerequisite events	
	F^{23} Unplanned Congressional adds to PB request	
	F^{24} Use of undefinitized contract action delays	

ACAT I. Funding and requirements factors (F^{18}, F^{19}, F^{23}, and F^{26}) previously ranked above $\bar{x}$ dropped below $\bar{x}$ while Contractor proposal prep delays (F^{6}) rose markedly to become the highest impact factor. Component-directed POM adjustment (F^{17}) made a noticeable shift to the top nine factors (or one standard deviation above the mean).

ACAT II. Fifteen of the factors previously ranked above $\bar{x}$ dropped below $\bar{x}$ (leaving only F^{1}, F^{2}, F^{3}, and F^{17}). Four of the factors that fell below $\bar{x}$ included contracting-related factors (F^{4}, F^{6}, F^{8}, and F^{9}).

ACAT III. Six of the factors (F^{16}, F^{18}, F^{19}, F^{21}, F^{23}, and F^{24}) previously ranked above $\bar{x}$ dropped below $\bar{x}$. Shortages of personnel (F^{29}, F^{30}, F^{39}, and F^{51}) and Redirection of contractor efforts (F^{37}) became more dominating issues for the respondents. Changes in user priorities (F^{19}), Changes in other stakeholder requirements (F^{13}), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F^{26}) all moved significantly above $\bar{x}$.

What does this mean? The more detailed differentiation seen in the scatter plots gives additional insight into the factors that would benefit from a more focused investigation of each ACAT. In some cases, reducing frequency of occurrence or perhaps instituting more early warning metrics could have a marked effect in reducing any adverse impacts.

Factor Plotting—Modulating Service Components and DoD

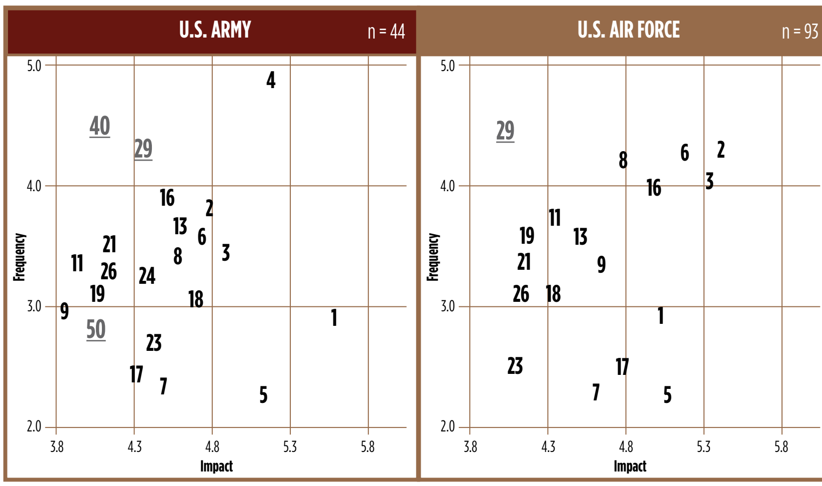
Figure 6 shows how the factor rankings changed after isolating Service Components.

U.S. Army. No factors fell below $\bar{x}$. The only component where factors moved above $\bar{x}$ was Shortage of auditors (F^{40}) and Insufficiently planned Overseas Contingency Operations (OCO) funding (F^{50}). Based on historical information, OCO funding will most likely continue to present challenges since contingency funding needs are less predictable during a wartime footing.

U.S. Air Force. Shortage of contracting officers (F^{4}) and Use of undefinitized contract action delays (F^{24}) both dropped below $\bar{x}$. Even though Shortage of contracting officers moved, there were no companion drops in contracting-related factors.

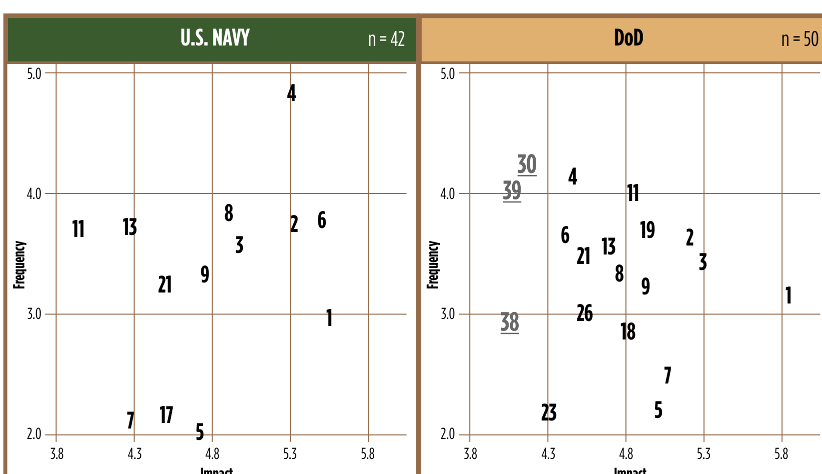
U.S. Navy. Six factors dropped below $\bar{x}$. Implementation of new OSD/Service Policy (F^{16}), Awaiting reprogramming action (F^{18}), Changes in user priorities (F^{19}), Unplanned Congressional adds to PB request (F^{23}), Use of undefinitized contract action delays (F^{24}), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F^{26}) became less of an impact. For Navy respondents, there was no notable movement in the top six contracting-related factor collective.

FIGURE 6. FACTOR RATINGS ≥ $\bar{x}$ BY COMPONENT



Factor Increase:
F40 Shortage of auditors
F50 Insufficiently planned OCO funding

Factor Decrease:
F4 Shortage of contracting officers
F24 Use of undefinitized contract action delays



Factor Decrease:
F16 Implementation of new OSD/Service policy
F18 Awaiting reprogramming action
F19 Changes in user priorities
F23 Unplanned Congressional adds to PB request
F24 Use of undefinitized contract action delays
F26 Loss of funding through reprogramming action to higher priority requirements to PEO portfolio

Factor Decrease:
F16 Implementation of new OSD/Service policy
F17 Component-directed POM adjustment
F24 Use of undefinitized contract action delays

Factor Increase:
F30 Shortage of business/finance personnel
F38 OSD Comptroller Withhold
F39 Shortage of technical/engineering/testing personnel

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DoD. Three factors fell below $\bar{x}$ (i.e., Implementation of new OSD/Service policy [F^{16}], Component-directed POM adjustment [F^{17}], and Use of undefinitized contract action delays [F^{24}]), while three factors rose above $\bar{x}$: OSD Comptroller Withhold (F^{38}), Shortage of business/finance personnel (F^{30}), and Shortage of technical/engineering/test personnel (F^{39}).

What does this mean? The Army was the only one of the four groupings that was significantly affected by Use of undefinitized contract action delays (F^{24}); and DoD was the only one of the four groupings that was significantly affected by OSD Comptroller Withhold (F^{38}), Shortage of business/finance personnel (F^{30}), and Shortage of technical/engineering/test personnel (F^{39}).

Factor Plotting—Modulating Respondent Groups

Figure 7 shows how the factor rankings changed after isolating the respondent groups.

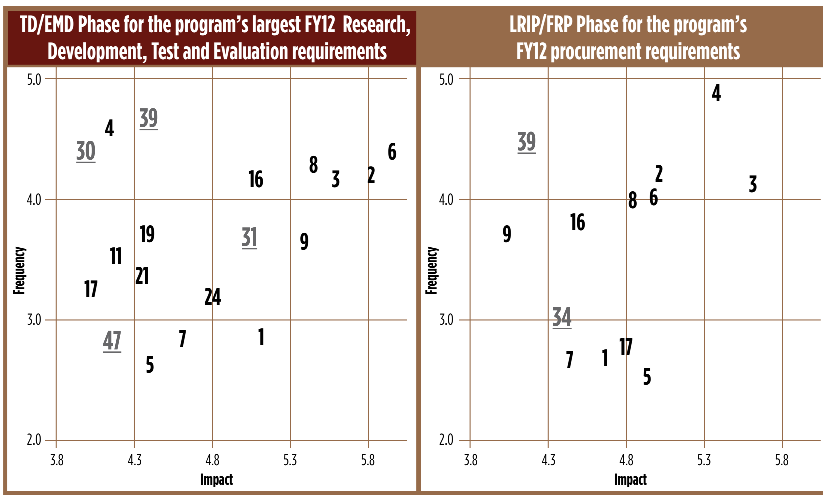
Program Office. Six factors dropped below $\bar{x}$: Awaiting reprogramming action (F^{18}), Changes in user priorities (F^{19}), Program delays from additional development, testing, or other prerequisite events (F^{21}), Unplanned Congressional adds to PB request (F^{23}), Use of undefinitized contract action delays (F^{24}), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F^{26}). No factors fell below $\bar{x}$.

PEO. Use of undefinitized contract action delays (F^{24}) fell below $\bar{x}$, while four factors rose above $\bar{x}$: Shortage of cost estimators (F^{29}), Shortage of business/finance personnel (F^{30}), Component Comptroller Withhold (F^{35}), and Insufficiently planned OCO funding (F^{50}).

Senior OSD Staff. Awaiting reprogramming action (F^{18}) fell below $\bar{x}$ while 13 factors rose above $\bar{x}$.

For PEO and senior OSD staff, personnel shortages (F^{29}, F^{30}, F^{20}, and F^{40}) became more dominant while Awaiting reprogramming action (F^{18}) became less dominant for program office and senior OSD staff personnel. Of the three groupings in this particular case, nowhere were there more factor increases than for senior OSD staff personnel. The rise in Unobligated prior year funding not adequately factored (F^{34}), SAE/CAE/

FIGURE 7. FACTOR RATINGS ≥ $\bar{x}$ WHEN NEGOTIATED CONTRACT COSTS WERE LOWER THAN COSTS PROJECTED



Factor Decrease:

F^{13} Changes in other stakeholder requirements
F^{18} Awaiting reprogramming action
F^{23} Unplanned Congressional adds to PB request
F^{26} Loss of funding through reprogramming action to higher priority requirements to PEO portfolio

Factor Increase:

F^{30} Shortage of business/finance personnel
F^{31} Programmatic conflicts between government and prime contractor
F^{39} Shortage of technical/engineering/testing personnel
F^{47} Holding award/incentive fees in commitment for future obligation

Factor Decrease:

F^{11} Changes in user requirements
F^{13} Changes in other stakeholder requirements
F^{18} Awaiting reprogramming action
F^{19} Changes in user priorities
F^{21} Program delays from prerequisite events
F^{23} Unplanned Congressional adds to PB request
F^{24} Use of undefinitized contract action delays
F^{26} Loss of funding through reprogramming action to higher priority requirements to PEO portfolio

Factor Increase:

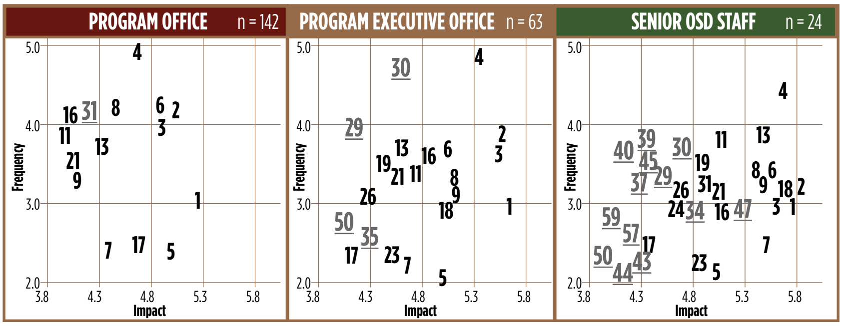
F^{34} Unobligated prior year funding not adequately factored
F^{39} Shortage of technical/engineering/testing personnel

Component-directed reprogramming (F^{43}), and PEO-directed programming (F^{59}) seemed intuitive since senior staff may see first-hand the longer time it takes for program managers to react to changes in their plans. However, it was very interesting to note the disparities between how senior OSD staff personnel responded to survey queries regarding the major impediments to meeting OSD's Obligation and Expenditure rate goals versus the responses from program office personnel, especially shortage of personnel and contract-specific factors (i.e., Changes in systems specs (F^{45}) and Redirection of contractor efforts (F^{37}). What does this mean? This wide perception disparity deserves a more intensive understanding since it could be creating false perceptions that could lead to misrepresented positions and even unsubstantiated decisions.

Factor Plotting—Modulating Program Phase and Cost Projections

Figure 8 shows how the factor rankings changed after modulating by program phase when their negotiated contract costs were significantly lower than projections.

FIGURE 8. FACTOR RATINGS ≥ $\bar{x}$ BY POSITION



Program Office	Program Executive Office	Senior OSD Staff
Factor Decrease:	**Factor Decrease:**	**Factor Decrease:**
F18 Awaiting reprogramming action	F24 Use of undefinitized contract action delays	F18 Awaiting reprogramming action
F19 Changes in user priorities	**Factor Increase:**	**Factor Increase:**
F21 Program delays from prerequisite events	F29 Shortage of cost estimators	F29 Shortage of cost estimators
F23 Unplanned Congressional adds to PB request	F30 Shortage of business/finance personnel	F30 Shortage of business/finance personnel
F24 Use of undefinitized contract action delays	F35 Component Comptroller Withhold	F34 Unobligated prior year funding not adequately factored
F26 Loss of funding through reprogramming action to higher priority requirements to PEO portfolio	F50 Insufficiently planned OCO funding	F37 Redirection of contractor efforts
		F39 Shortage of technical/engineering/testing personnel
		F40 Shortage of auditors
		F43 SAE/CAE/Component-directed reprogramming
		F44 Rescission
		F45 Changes in systems specs
		F47 Holding award/incentive fees in commitment for future obligation
		F50 Insufficiently planned OCO funding
		F57 Termination liability
		F59 PEO-directed programming

Development Phase (Technology Development [TD] and Engineering, Manufacturing, and Development [EMD]). Four factors dropped below $\bar{x}$, including Changes in other stakeholder requirements (F13), Awaiting reprogramming action (F18), Unplanned Congressional adds to PB request (F23), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F26). Four factors rose above $\bar{x}$, including Shortage of business/finance personnel (F30), Programmatic conflicts between government and prime

contractor (F^{31}), Shortage of technical/engineering/test personnel (F^{39}), and Holding award/incentive fees in commitment for future obligation (F^{47}). In two cases, Programmatic conflicts between government and prime contractor (F^{31}) and Implementation of new OSD policy (F^{16}) made a noticeable shift to the top nine factors (or one standard deviation above the mean).

Procurement Phase (Low Rate Initial Production [LRIP] and Full Rate Production [FRP]). Eight of the factors that previously ranked above $\bar{x}$ dropped below $\bar{x}$. The majority of the movement was seen in factors involving program delays, and funding and requirements changes. The factors involving program delays included Program delays from additional development, testing, or other prerequisite events (F^{21}), and Use of undefinitized contract action delays (F^{24}). The factors involving funding delays included Unplanned Congressional adds to PB requests (F^{23}), and Awaiting reprogramming action (F^{18}). The factors involving requirements changes included Changes in user requirements (F^{11}), Changes in other stakeholder requirements (F^{13}), Changes in user priorities (F^{19}), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F^{26}). Both Unobligated prior year funding not adequately factored (F^{34}) and Shortage of technical, engineering, and test personnel (F^{39}) rose above $\bar{x}$.

In both phases, Changes in other stakeholder requirements (F^{13}), Awaiting reprogramming action (F^{18}), Unplanned Congressional adds to PB requests (F^{23}), and Loss of funding through reprogramming action to higher priority requirements to PEO portfolio (F^{26}) fell below $\bar{x}$. In the context of modulating by program phase, the researchers found that any factor movement was negligible when costs met or exceeded projections.

What does this mean? Changes in user requirements (F^{11}) could potentially be more stable during the production phase and no longer become a factor. However, the emergence of Programmatic conflicts between government and prime contractor (F^{31}) during the development phase could perhaps be the sign of competing motivations between DoD and industry as well as more prominent technical and schedule risks. All three could result in programmatic delays.

Respondent Comments Regarding the Factors

The respondents were also asked several open-ended questions about whether they found the use of metrics helpful in better meeting OSD goals as well as any process improvements they would recommend. They stated the metrics making a difference for them included "real-time monitoring, frequent reviews, tight coupling to contractor actions and milestones, and realistic spend plans." When asked about any necessary improvements to current processes, the respondents recommended including a CRA duration variable that readjusted expectations, establishing more realistic program goals, ensuring more funding stability, reducing bureaucratic obstacles and streamlining more

FIGURE 9. SAMPLING OF RESPONDENT COMMENTS

X_1 Personnel, Tools & Training	*"Takes too long to get Acquisition Strategies and Acquisition Plans written and approved."* *"Personnel do not have experience with the subject matter."*
X_2 Contracting Activities	*"Inadequate proposals, protracted negotiations, lengthy audits, and lengthy pre-award processes."*
X_3 Requirements Stability	*"Had to defer/re-prioritize requirements execution and carry forward funding to cover cutbacks/shortfall."* *"Changes in requirements precipitated by other stakeholders' actions and ill-defined requirements."* *"User leadership routinely changes requirement & priorities."*
X_5 Business Ops	*"MIPR [Military Interdepartmental Purchase Request] billing process can delay expenditures from 90 to 120 days."* *"Delays in negotiating best deal for gov't and sometimes delays in getting acceptable proposals."*
X_6 Senior-level Execution Reviews	*"Extensive reviews, too long to get decision briefs through oversight layers—not always value added."* *"Multiple instances where milestone documentation took upwards of 9 months to a year to get approved."*
X_7 Funding Realities	*"The problem isn't unrealistic or overly optimistic spend plans as much as it's not knowing when funds will be appropriated and how much will be apportioned by the executing organization."*

outdated processes, forging greater cooperation between government and industry, and synchronizing disparate accounting systems used in Obligation and Expenditure reporting.

The respondents provided a number of additional qualitative comments that reinforced the quantitative data, especially for the factors above $\geq \bar{x}$ that were causing obligation rate interference.

Recommendations

What next? Based on the research findings presented in this article, a number of impact factors above $\bar{x}$, if sufficiently addressed, could help lower the barriers to the attainment of OSD's Obligation and Expenditure rate goals. Hence, the researchers offer the following recommendations:

- Institute an Obligation and Expenditure baseline adjustment for programs affected by any funding delay or limitation (especially CRA), then measure a program's progress to that revised adjustment.

- More thoroughly review the entire contracting action value chain. Look closely at efficiency opportunities along the review and decision cycle continuum, especially from the time an RFP is developed to the time a contract is let. Set reasonable time thresholds with triggers that afford more proactive measures by PMs—and confirm productivity.

- Establish a recurring communication forum among key stakeholders, especially PMs and OSD, to dialogue more frequently and eliminate perception gaps that could be creating counterproductive actions and misconceptions.

- Track requirement changes throughout a program's life and look more strategically at the effects on program execution and accompanying Acquisition Program Baselines. Despite ACAT levels, an obvious ripple effect is associated with any substantive change in program content across a program's life that should be codified more comprehensively. However, there are also issues associated with different ACAT levels, which must be noted.

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- Review the program review cycle and streamline wherever possible. Checks and balances within the DoD's acquisition community have always been a vital constituent component of program execution, but every review should have a distinctive purpose, exit criteria, and associated suspense date that is just as material and credible.

- Build and maintain realistic spend plans, measure against them, account for contingencies, and make adjustments with required frequency due to real world realities. Since spend plans are subjected to so many real world programmatic eventualities, updating them is vital. Collaborate with senior leadership early enough about required adjustments to avoid more draconian measures later.

- Validate the key personnel shortage areas and recognize the time it takes to rebuild those experience levels.

- Nurture experience in key functional areas with strong catalysts such as disciplined on-the-job training, programs, mentoring, and guidance. With the recent surge of contracting specialist interns, their progress as a group should be measured more carefully.

- Evaluate the real effects of reprogramming action or realignment of future budget decisions before any corrective action is taken.

- Conduct a wholesale review of the program execution metrics currently in place and determine their usefulness and effectiveness. What are they actually measuring? How are these data (metrics) used and are they worth collecting? Consolidate whenever practical and eliminate the data (metrics) that have outlived their usefulness.

- Encourage innovation and avoid the "bookkeeping process" as RAND Corporation found in a recent study that could be limiting improvements championed by PMs (Blickstein & Nemfakos, 2009).

Summary

On Feb. 5, 2013, the authors presented the study results discussed in this article to Assistant Secretary of Defense for Acquisition Katrina McFarland and other key OSD senior staff. With the metrics she plans to institute with *Better Buying Power (BBP) 2.0*, DoD will have another means to address many of the impact factors discussed herein and a host of other variables that could be encumbering program execution expectations.

On Sept. 10, 2012, Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall, and Under Secretary of Defense (Comptroller) Robert F. Hale, jointly signed a memorandum that listed six tenets that could help combat some of the same factors discussed in this article regarding the disposition of DoD's unobligated funds (DoD, 2012). Over time, realization of these tenets might also reduce perception disparity gaps among the key personnel that have a hand in ensuring our warfighters continue to get the weapon systems they need—and on time—to best support our national military strategy.

6

Author Biographies

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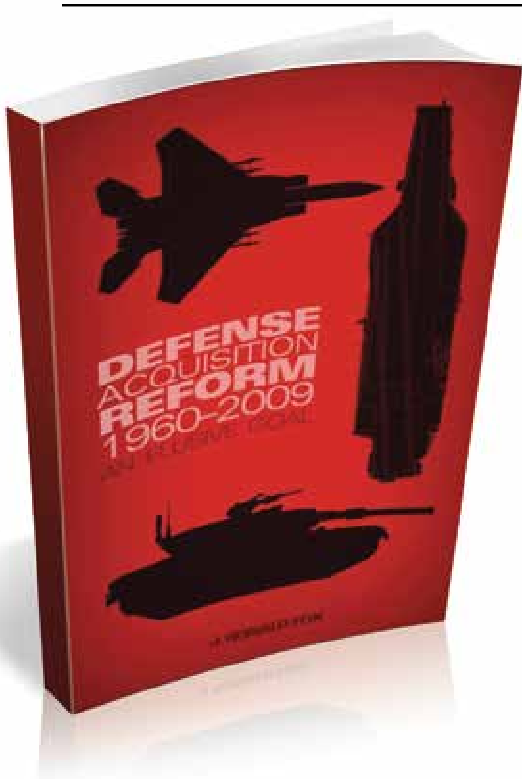
The Defense Acquisition Professional Reading List is intended to enrich the knowledge and understanding of the civilian, military, contractor, and industrial workforce who participate in the entire defense acquisition enterprise. These book reviews/recommendations are designed to complement the education and training that are vital to developing the essential competencies and skills required of the Defense Acquisition Workforce. Each issue of the *Defense Acquisition Research Journal (ARJ)* will contain one or more reviews of suggested books, with more available on the *Defense ARJ* Web site.

We encourage *Defense ARJ* readers to submit reviews of books they believe should be required reading for the defense acquisition professional. The reviews should be 400 words or fewer, describe the book and its major ideas, and explain its relevance to defense acquisition. Please send your reviews to the Managing Editor, *Defense Acquisition Research Journal*: *Norene.Fagan-Blanch@dau.mil.*



Featured Book

Defense Acquisition Reform, 1960–2009: An Elusive Goal

Author(s):
J. Ronald Fox

Publisher:
Center of Military History, United States Army

Copyright Date:
2011

Available Online:
http://www.history.army.mil/html/books/051/51-3-1/index.html

Hard/Softcover:
PDF, 287 pages

Reviewed by:
John Alic, former staff member of the congressional Office of Technology Assessment

Review:

The Harvard Business School's J. Ronald Fox, a long-time student of acquisition, prepared this volume drawing on work by the other contributors. All five have been associated with the Defense Acquisition History Project. Although the book's front matter implies that the project ended in 2009, incomplete, in fact it is now housed in the Historical Office of the Office of the Secretary of Defense and further volumes can be expected. This is something to look forward to, since Fox's volume itself offers little that is new; as a review of past studies, it will be most useful to newcomers to the subject of acquisition reform.

There are some fresher sections. In one of these, Fox and his colleagues relate how the Air Force, Navy, and to a lesser extent the Army, sought, with considerable success, to circumvent or otherwise neutralize provisions of the 1986 Goldwater-Nichols Act (see pp. 127–146). Mostly, however, and despite considerable use of oral histories and internal DoD documents, Defense Acquisition Reform adds only marginally to our understanding. This is not so much a criticism of the book as an acknowledgement of how many studies have gone over the ground reviewed, reaching many of the same conclusions.

What is needed most is analytical insight. Six decades of attempts at reform have largely failed. The message is plain in Defense Acquisition Reform, if largely implicit, soft-peddled even in the subtitle.

The book's treatment of workforce quality illustrates the unsatisfactory state of analysis. The subject is one that Fox has examined previously and mentions repeatedly here. It is well and good to urge more and better training of the acquisition workforce, stronger incentives for exemplary performance, and lengthier tenures, especially for program managers, to build capability through experience. But a quick glance at the private sector is enough to show that a skilled and experienced workforce is no assurance of organizational performance. For decades, U.S.-based firms like General Motors and IBM had their pick of the best graduates of the best schools. With the help of formal training and internal labor markets that rewarded experiential learning, they held onto many of these employees. IBM, after running into competitive difficulties some years ago, managed to revivify itself. But smart

and capable employees were not enough for GM to find its way out of the organizational routines that entrapped the firm beginning in the 1950s. Will GM finally make it this time? How about Hewlett-Packard? Sony? DoD would certainly benefit from a better qualified acquisition workforce. Yet how much difference would this actually make for major programs dominated by bureaucratic power politics? The audience for studies of acquisition, certainly the policy-making audience, would benefit from attempts to answer questions of this sort, no matter how tentative the answers might be.

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